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ABSTRACT: Although hollinid ostracods from the Middle Devonian Jeffersonville limestone at the Falls of the Ohio have been known for many years, a detailed study reveals a new genus, *Flaccivelum*, and fifteen new species, belonging to the genera *Abditoloculina*, *Ctenoloculina*, *Hollina*, *Hollinella*, and *Subligaculum*. Nine other species, belonging to the genera *Abditoloculina*, *Adelphobolbina*, *Flaccivelum*, *Hollina*, and *Hollinella*, have been previously described. Many of the species of *Abditoloculina* are closely related, but can be distinguished by the number of loculi in the female.

Middle Devonian hollinid ostracods from the Falls of the Ohio

ROBERT V. KESLING AND REX M. PETERSON

Museum of Paleontology
University of Michigan
Ann Arbor, Michigan

INTRODUCTION

Excellently preserved fossils occur in the Middle Devonian Jeffersonville limestone at the famous locality known as the Falls of the Ohio, on the Ohio River between Louisville, Kentucky, and Jeffersonville, Indiana. In small pockets at the surface, naturally weathered Bryozoa, ostracods, and other small fossils are concentrated. For years, these pockets provided rich material to many museums. Now they are scarce. Although the microfossils are silicified and very brittle, most are completely weathered from the matrix and require very little cleaning. The ostracod fauna of the Jeffersonville limestone includes many families in addition to the Hollinidae, which we have made the subject of this study. The ostracods described here are from a sample given to the Museum of Paleontology of the University of Michigan more than a quarter of a century ago by Dr. R. S. Bassler, to whom we express our profound thanks.

The hollinid ostracods described here include seven genera and twenty-three species, of which one genus and fifteen species are new. In addition, there are four males of the genus *Abditoloculina* that are designated only by letter, for lack of sufficient evidence to assign them to species with the corresponding females.

All specimens figured in this paper are catalogued and deposited in the Museum of Paleontology of the University of Michigan.

STRATIGRAPHY

The Jeffersonville limestone is of Middle Devonian age and is correlated with the Onondaga limestone

of New York. It has been well described in the region of the Falls of the Ohio by Campbell (1942). It overlies the Silurian Louisville dolomite and is overlain by rocks of the Middle Devonian Hamilton group. On the Indiana side of the Falls at Jeffersonville, twenty-nine feet of the Jeffersonville limestone is exposed and is overlain successively by the Silver Creek and Beechwood formations. Here the Jeffersonville limestone consists of nine feet of coral zone with *Meristella nasuta*, ten feet of "*Spirifer*" *gregarius* zone, and ten feet of "*Spirifer*" *acuminatus* zone. The last is a thick-bedded, white to gray limestone with several cherty layers; the thin basal layer is filled with ostracods and bryozoa. It was from this bed that Dr. Bassler collected the material yielding the ostracods described here.

PREVIOUS WORK

Middle Devonian hollinid ostracods from the eastern United States have been described by Jones (1890), Ulrich (1890-1891, 1900), Ulrich and Bassler (1908), Coryell (1928), Coryell and Malkin (1936), Swartz (1936), Warthin (1934), Bassler (1941), Stover (1956), and Kesling and his students during the past several years.

Ulrich's excellent works (1890-1891, 1900) included some of the common hollinids from the Falls of the Ohio. However, a surprisingly large number of hollinid ostracods remained undiscovered. Perhaps additional species will yet be found when more material is worked over.

TABLE 1
KEY FOR IDENTIFICATION OF FEMALE VALVES OF *Abditoloculina* SPECIES FROM THE JEFFERSONVILLE LIMESTONE

Number of loculi	Frill with thick lateral rim; L3 a bulb		Frill with thin distal rim; L3 a bulb		Frill plain, without rim; L3 a low lobe	
	Loculi with lunate outer lip	Loculi with small simple rim	No posterior nodes	Two posterior nodes	L1 lobate, dorsally projecting	L1 small, not above hinge line
7			<i>A. insolita</i>	<i>A. binodata</i>		
8	<i>A. palpebrata</i>					<i>A. repanda</i>
9	<i>A. obesivelata</i>	<i>A. fundiornata</i>			<i>A. prominens</i>	<i>A. pusilla</i>
10	<i>A. clavicavosa</i>				<i>A. eminens</i>	<i>A. pumila</i>
11						<i>A. cavimarginata</i>

SYSTEMATIC DESCRIPTIONS

Order OSTRACODA

Family HOLLINIDAE Swartz, 1936

Genus *Abditoloculina* Kesling, 1952

Type species: Abditoloculina insolita Kesling, 1952, pp. 765, 767-768, pl. 111, figs. 7-14, by original designation.

Diagnosis: Hollinid genus with each valve trilobate, having a distinct lobe, knob, or bulb for L3; the posterior part of each valve flat to gently convex, without any development of an L4; each female valve with loculi and spurs; and each male valve with velate spurs and a divided velate ridge, the first part from the anterior region onto the front spur and the second part from below the front spur to the posteroventral region.

Remarks: Species of this genus are known only from Middle Devonian strata. Some undescribed species occur in the Traverse group (Hamilton) of Michigan.

Many of the ostracods assigned to *Abditoloculina* from the Jeffersonville limestone are closely related. We have distinguished several solely on the basis of the number of loculi in the female. We should be extremely wary of this criterion were it not for the fact that the loculi in the 8-loculate, 9-loculate, and 10-loculate ostracods are differently spaced. The presence of another loculus is not a simple supernumerary addition at the posterior end of the frill; instead, all loculi are smaller and crowded together, so that each loculus lies in a different position with respect to the lobes, sulci, and spurs. Loculi are distinct, complex structures, and their arrangement, in our opinion, cannot be regarded as fortuitous; therefore, the ostracods with eight, nine, and ten loculi belong to different species. In addition, in such closely related species as *Abditoloculina palpebrata*, *Abditoloculina obesivelata*, and *Abditoloculina clavicavosa*,

the ostracods with different numbers of loculi differ slightly in lobation and development of spurs.

Unfortunately, several of the species are so closely related that they can be separated only on the characteristics of the females. Males of these species are here designated only by letter; the corresponding females are not known with certainty. *Abditoloculina armata*, described from a male valve by Ulrich, is here retained as a separate species because we are not sure whether it is a male of *Abditoloculina clavicavosa*, *Abditoloculina fundiornata*, or *Abditoloculina cavimarginata*, or whether it is a valid species of which the female dimorph has not been discovered.

It appears that Jeffersonville time was an age of great specific proliferation of *Abditoloculina*. The characteristics showing most variation are the shape of the frill, the spurs, the size of L1 and L3, and the number of loculi. As would be expected, during such rapid evolution all characteristics did not respond simultaneously or to the same degree. Lobation seems to have been the most conservative characteristic and the number of loculi the least conservative, inasmuch as some species vary only slightly in their lobation but have different numbers and spacing of loculi.

Abditoloculina binodata Kesling and Peterson, new species

Plate 1, figures 42-47

Diagnosis: Small *Abditoloculina* species with each female valve having a thin distal rim on the frill, two posterior nodes, seven loculi, and the anterior spur on the convexity of the frill marking the third loculus.

Female: Valve elongate subelliptical to subpyriform in lateral view. Hinge line straight, anterior border round, ventral border gently curved, and posterior border

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subround. Anterior and ventral parts of free edge concealed by the frill.

Trilobate; L1 a low, elongate lobe near the anterior corner; L2 a conspicuous knob separated from the dorsal border by about one-sixteenth of the height of the valve, slightly smaller than L3; and L3 bulbous, with high relief, extending above the hinge line, bearing a short posterodorsal spine, and having a diameter equal to about one-third the height of the valve. Posterior part of the valve nearly flat, only slightly convex. Two small, conspicuous knob-like nodes on the posterior part of the valve, of about equal size and shape; the dorsal one tangent to the hinge line near the posterior corner, and the ventral one below it at about the same height as the dorsal edge of the rear spur. S1 shallow, separating L1 and L2; S2 moderately deep, S-shaped, extending from the hinge to the frill, passing between L2 and L3 and around the anterior end of the rear spur.

Spurs subconical, posteriorly directed. Anterior spur much smaller than posterior, extending onto the dorsal part of the convexity of the frill marking the third loculus. Posterior spur curved, its base located below the front edge of L3 and above the frill (approximately between the convexities marking the fifth and sixth loculi).

Frill with a narrow, delicate distal rim, and distinct lateral ovate convexities marking the positions of the loculi. Seven nearly round loculi. Each loculus rimmed by a narrow crest. Submarginal ridge small, low, bearing closely spaced, very small papillae. As seen in anterior view, the partitions between the loculi have their ventral surfaces set at an angle of about 70 degrees to the contact margin of the valve.

Lateral surface granular. Anterior and posterior cardinal angles about 120 and 130 degrees.

Dimensions of holotype, an almost complete left valve: Length 0.90 mm.; height 0.52 mm.; width (exclusive of spurs) 0.24 mm.

Remarks: This species closely resembles the type species, *Abditoloculina insolita* Kesling (1952, pp. 767-768, pl. 111, figs. 7-14), and *Abditoloculina pulchra* Kesling (1955, pp. 274-276, pl. 1, figs. 1-19). It differs from *Abditoloculina insolita* (see Table 1) in having a larger L2, which is a knob rather than a node; the anterior spur extending onto the frill convexity marking the third loculus rather than the second; a smaller and less curved posterior spur; and two nodes on the posterior part of the valve instead of a single small tubercle between L3 and the posterior corner. *Abditoloculina binodata* differs from *Abditoloculina pulchra*, from the Hamilton group, in having seven instead of eight loculi, a small posterodorsal spine on L3, posterior nodes, and a simple conical anterior spur rather than a dumbbell-shaped structure.

The name of this species is derived from the Latin *bi* ("two-, double") and *nodus*, m. ("a node"), and refers to the two posterior nodes on the valve.

Types: Holotype, an almost complete female left valve, no. 34679. Paratype, an incomplete female right valve, no. 34680.

Abditoloculina cavimarginata (Ulrich)

Plate 1, figures 19-21

Ctenobolina cavimarginata ULRICH, 1900 (in part), p. 182, pl. 8, figs. 8-9 (not fig. 7). — ELLIS AND MESSINA, 1952 (in part), unnumbered page, figs. 8-9 (not fig. 7).

Hollina cavimarginata (Ulrich). — ULRICH AND BASSLER, 1908 (in part), p. 315, pl. 42, figs. 11-12 (not fig. 10). — GRABAU AND SHIMER, 1910 (in part), p. 357, text-fig. 1660w, x (not fig. 1660w). — BASSLER AND KELLETT, 1934 (in part), p. 329. — SWARTZ, 1936, p. 552, pl. 80, fig. 3c. — WARTHIN, 1937 (in part), card 72, figs. 8-9 (not fig. 7).

Abditoloculina cavimarginata (Ulrich). — KESLING, 1952 (in part), p. 767. — POKORNÝ, 1954 (in part), text-fig. 531 (lower two figures only).

Diagnosis: Large *Abditoloculina* species with each female valve having an almost flat frill without a lateral rim, a small L1, a low lobate L3, and eleven loculi.

Supplementary description of female: Valve subelliptical to subpyriform in lateral view. Hinge line straight. Anterior and ventral borders round, without indentations to mark the positions of the loculi. Posterior border gently curved.

Trilobate; L1 small, not projecting above hinge line, L2 an ovate knob, and L3 an ovate lobe extending slightly above the hinge line. Posterior part of valve low, continuous with a broad diagonal ridge extending below L3 to the posterior spur. S2 narrow and rather deep, extending from hinge line to the ventral border. Posteroventral part of valve flat, separated from the slightly arched posterior part of the valve by a broad semisulcus.

Anterior spur knob-like, essentially the same size as L2, without a sharp projection. Posterior spur massive, with a thick base and a blunt posteroventral tip.

Frill plain, flat, continuous with the lateral surface of the valve. As seen in ventral view, eleven subovate to subtriangular loculi. Partitions between loculi meeting the frill with smooth junctions; each partition with very faint lateral ridges, forming rims of the loculi, and shallow, indistinct transverse grooves; the narrowest part of each partition about half as wide as the adjacent loculus. Submarginal structure proximal to loculi, level with partitions between the loculi. Narrow marginal ridge, separated from submarginal structure by a very narrow groove or channel.

Lateral surface smooth to finely granular. Corners somewhat round; anterior and posterior cardinal angles about 120 and 135 degrees, respectively.

Dimensions of topotype, no. 34671, a right valve: Length 1.08 mm.; height 0.69 mm.; width (including spur) 0.42 mm.

Remarks: An examination of the syntypes (labeled "cotypes"), U. S. National Museum, no. 41495, shows that the original description and illustrations of *Abditoloculina cavimarginata* (Ulrich) were composites of two species. As lectotype we here designate the specimen illustrated by Ulrich (1900) in pl. 8, figs. 8-9. The other specimen (Ulrich's pl. 8, fig. 7) belongs to a new species, described below as *Abditoloculina obesivelata*.

Abditoloculina cavimarginata resembles *Abditoloculina pumila*, n. sp., but differs in having eleven loculi instead of ten, a much thicker and more massive spur, larger and more convex lobes, and thicker partitions between the loculi.

Illustrated specimen: Topotype, a female right valve, no. 34671.

***Abditoloculina clavieavosa* Kesling and Peterson,
new species**

Plate 1, figures 10-12

Diagnosis: Large *Abditoloculina* species with each female valve having a thick lateral rim on the frill, a lunate outer lip on each loculus, and ten loculi.

Female: Valve large, subelliptical to suboval in lateral view. Posterior part of valve broken off in holotype and only specimen. Hinge line straight, anterior border subround, and ventral border gently curved. Most of free border hidden by frill.

Trilobate; L1 a small knob at the anterior corner, with a long posterodorsal tubercle extending above the hinge line; L2 large, bulbous, larger than L1 or L3; and L3 bulbous, slightly smaller than L2 but larger than L1, extending slightly above hinge line. S1 very narrow, separating L1 and L2; S2 deep, long, sinuous, extending from hinge line to the lateral rim of the frill, passing between L2 and L3 and between the two spurs. Low ridge, broad, slanting, connecting the posterodorsal part of the valve to the rear spur and rising above the flat posterior part of the frill.

Spurs distinct, curved posteriorly. Anterior spur smaller, its base sloping anteroventrally, its tip bent sharply backward. Posterior spur larger, subconical, directed outward and slightly backward.

Frill with a thick lateral rim extending sharply outward, nodose in the anterior part, set close under the spurs. Ventral surface of lateral rim and partitions between the loculi ornamented with small, closely spaced longitudinal crests. Ten deep loculi, each suboval to keyhole-shaped, surrounded by a distinct rim. Rim narrow except in distal part, there enlarged to form a lunate outer lip of the loculus. Distally, each partition about half as wide as the adjacent loculus; proximally, much wider than the loculus. Marginal ridge separated by a narrow channel from the loculate part of the valve. Lateral surface granular, covered with irregular, very shallow depressions, like dents.

Dimensions of holotype, a broken left valve: Height 0.73 mm.; width (including spur) 0.47 mm. Length estimated to have been 1.15 to 1.20 mm.

Remarks: This species resembles *Abditoloculina obesivelata*, *Abditoloculina fundiornata*, and *Abditoloculina palpebrata*, described below, in having a thick lateral rim on the frill; it can be distinguished from all of them by its greater number of loculi. As shown in Table 1, *Abditoloculina eminens* and *Abditoloculina pumila* also have ten loculi, but both of them have a plain frill without any lateral rim.

The name of this species is derived from the Latin *clavis*, f. ("key"), and *cavum*, n. ("a hole, cavity"), and refers to the keyhole-shaped loculi.

Type: Holotype, a broken female left valve, no. 34667.

***Abditoloculina eminens* Kesling and Peterson,
new species**

Plate 1, figures 25-27

Diagnosis: Large *Abditoloculina* species with each female valve having an almost flat frill without a lateral rim, a large linguiform L1, a low lobate L3, ten loculi, a low node-like anterior spur, and a massive and blunt posterior spur.

Female: Valve subpyriform in lateral view. Hinge line straight, anterior and ventral borders round, and posterior border subround. Posterior end acuminate. Frill extending very little beyond the free edge. Positions of loculi not apparent in lateral view of the frill.

Trilobate; L1 a large, linguiform lobe, gently convex, extending well above the hinge line; L2 a conspicuous but low, vertically elongate lobe extending nearly to the dorsal border; and L3 a very low, poorly defined, small lobe extending slightly above the hinge line. Posterior part of the valve very gently convex, nearly flat. S1 a short shallow groove between L1 and L2; S2 a deeper groove, sinuous, passing between L2 and L3 and between the spurs.

Anterior spur a low lobe ventral and slightly anterior to L2. Posterior spur massive, blunt, directed outward and backward.

Frill flat, without rim of any kind. Ten subovate loculi. Partitions between loculi bearing faint transverse grooves, their narrowest parts about half as wide as the loculi. A shallow groove forming the channel between the submarginal ridge and the proximal structure bounding the loculi. Submarginal ridge low, with faint papillae. Surface smooth to very finely granular.

Dimensions of holotype, an incomplete left valve: Height 0.67 mm.; width (including spur) 0.39 mm. Estimated length 1.05 mm.

Remarks: This is the first species of *Abditoloculina* discovered in which L1 is linguiform and much more

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prominent than L3. It most closely resembles *Abditoloculina prominens*, from which it differs in having a shallower S2, a blunter posterior spur, and ten instead of nine loculi.

The name of this species is derived from the Latin *eminens* ("standing high, projecting"), and refers to the development of L1.

Type: Holotype, an incomplete female left valve, no. 34673.

Abditoloculina fundiornata Kesling and Peterson, new species

Plate 1, figures 13-15

Diagnosis: Large *Abditoloculina* species with each female valve having a thick lateral rim on the frill, a small simple rim around each loculus, and nine loculi.

Female: Valve elongate suboval in lateral view. Hinge line straight, anterior and posterior borders subround, and ventral border gently curved. Frill overhanging the free edge.

Trilobate; L1 a small, low lobe with a posterodorsal tip extending slightly above the hinge line, L2 and L3 knob-like, about equal in size, and L3 extending very slightly above the hinge line. Posterior part of valve only slightly convex. S1 very short and shallow; S2 sinuous, extending from hinge line to lateral rim of the frill.

Spurs adjacent to rim of the frill. Anterior spur small, subconical, directed backward. Posterior spur larger than anterior, bluntly horn-shaped, its tip directed backward.

Frill with a lateral rim, thicker in its anterior part. Ventral surface of lateral rim and partitions between the loculi ornamented with very thin, wavy longitudinal crests. Nine pear-shaped loculi, each with an extremely narrow, inconspicuous rim. Narrow submarginal ridge with very faint papillae, separated by a narrow, distinct channel from the part of the marginal surface bearing the loculi. Surface of valve granular.

Dimensions of holotype, a left valve: Length 1.16 mm.; height 0.68 mm.; width (including spurs) 0.38 mm.

Remarks: This species most closely resembles *Abditoloculina obesivelata*, from which it differs in having an extremely narrow rim around each loculus instead of a rim distally enlarged to form a lunate lip.

The name of this species is derived from the Latin *fundus*, m. ("the bottom or base of anything"), and *ornatus* ("ornamented"), and refers to the wide ornamented area on the ventral side of the lateral rim of the frill.

Type: Holotype, a female left valve, no. 34668.

Abditoloculina insolita Kesling

Plate 1, figures 39-41, 56-59

Abditoloculina insolita KESLING, 1952, pp. 767-768, pl. 111, figs. 7-14.

Diagnosis: Small *Abditoloculina* species with each female valve having a thin distal rim on the frill, a small tubercle on the dorsal border behind L3, seven loculi, the anterior spur on the convexity of the frill marking the second loculus, and the posterior spur exceptionally long, slender, and curved.

Remarks: The frill overhangs the free edge of the valve by almost its complete width. As can be seen in anterior view, the ventral surface of the partitions between the loculi is set at about 25 degrees to the plane of the contact margin.

Illustrated specimens: Two topotypes, female left valves, nos. 34677 and 34678. Allotype, a male right valve (here re-illustrated for comparison with other *Abditoloculina* males), no. 27779.

Abditoloculina obesivelata Kesling and Peterson, new species

Plate 1, figures 1-3

Ctenobolbina cavimarginata ULRICH, 1900 (in part), p. 182, pl. 8, fig. 7 (not figs. 8-9). - ELLIS AND MESSINA, 1952 (in part), unnumbered page, fig. 7 (not figs. 8-9).

Hollina cavimarginata (Ulrich). - ULRICH AND BASSLER, 1908 (in part), p. 315, pl. 42, fig. 10 (not figs. 11-12). - GRABAU AND SHIMER, 1910 (in part), p. 357, text-fig. 1660w (not figs. 1660w', x). - BASSLER AND KELLETT, 1934 (in part), p. 329. - WARTHIN, 1937 (in part), card 72, fig. 7 (not figs. 8-9).

Abditoloculina cavimarginata (Ulrich). - KESLING, 1952 (in part), p. 767. - POKORNÝ, 1954 (in part), text-fig. 531 (uppermost figure only).

Diagnosis: Large *Abditoloculina* species with each female valve having a thick lateral rim on the frill, a lunate outer lip on each loculus, and nine loculi.

Female: Valve subelliptical to subpyriform in lateral view. Hinge line straight. Anterior border round, ventral border broadly round, and posterior border subround. Anteroventral and ventral parts of free border hidden by frill.

Trilobate; L1 a low, small anterodorsal lobe with a small, inconspicuous tip extending slightly above the hinge line; L2 a large, distinct knob only a little way below the hinge line; and L3 conspicuously smaller than L2, bulbous, extending slightly above the hinge line. S1 short and narrow, separating L1 from L2; S2 sinuous, passing between L2 and L3 and between the spurs, terminating ventrally at the rim of the frill. Posterior part of the valve very gently convex, nearly flat.

Spurs distinct. Anterior spur with its base directed anteroventrally and its conical tip directed sharply backward. Posterior spur with a cylindrical base

pointing downward and outward and a short subconical tip directed backward.

Frill with a thick lateral rim, its anterior part thick and somewhat nodular. Ventral surface of lateral rim subreticulate, with short wavy crests more or less aligned longitudinally. Nine subovate loculi, each with a surrounding rim. Rim narrow except in distal part, there enlarged to form a lunate lip. Small submarginal ridge with numerous low, inconspicuous papillae. A very low ridge extending onto the lateral surface from the rear end of the frill, becoming only an angulation and reaching nearly to the posterior corner.

Lateral surface smooth to finely granular. Anterior and posterior cardinal angles about 130 and 120 degrees.

Dimensions of holotype, a female right valve: Length 1.18 mm.; height 0.67 mm.; width (including spurs) 0.46 mm.

Remarks: This species differs from *Abditoloculina cavimarginata* (Ulrich) in several ways: It has only nine instead of eleven loculi, its frill has a thick lateral rim, each loculus has a rim that is distally expanded to form a lunate lip, the spurs are smaller but more sharply pointed, and the L3 is smaller and more bulbous. However, one of the two syntypes selected for *Abditoloculina cavimarginata* by Ulrich (U. S. National Museum, no. 41495) belongs to this species, and we here designate it a paratype of the latter. *Abditoloculina obesivelata* more closely resembles *Abditoloculina fundiornata*, from which it differs in having a lunate outer lip at each loculus.

The name of this species is derived from the Latin *obesus* ("fat") and *velum*, n. ("frill"), and refers to the thick lateral rim on the frill.

Types: Holotype, a female right valve, no. 34665. Paratype, one of two valves on slide labeled "Cotypes, *Clenobolina cavimarginata*," U. S. National Museum, no. 41495.

***Abditoloculina palpebrata* Kesling and Peterson,
new species**

Plate 1, figures 4-6

Diagnosis: Large *Abditoloculina* species with each female valve having a thick lateral rim on the frill, a lunate outer lip on each loculus, and eight loculi.

Female: Valve suboval to subpyriform in lateral view. Hinge line straight, anterior border round, ventral border gently round, and posterior border subround. Frill overhanging the free edge.

Trilobate; L1 a low anterodorsal lobe with a small tip extending slightly above the hinge line, L2 a knob, and L3 knob-like, about the same size as L2, extending slightly above the hinge line. Posterior part of the valve very gently convex. S1 short and shallow; S2 sinuous, extending from the hinge line to the lateral rim of the frill.

Tips of both spurs broken off in holotype; bases of the spurs subconical, hollow. Posterior spur larger than anterior.

Frill with a thick lateral rim, its anterior part thicker and somewhat nodular. A very low, inconspicuous crest extending from the rear end of the frill onto the lateral surface, subparallel to the posterior border. Small subtriangular pit just behind the frill. Most of frill flat, but low, barely discernible convexities marking the positions of the last two loculi. Ventral surface of lateral rim and partitions between the loculi ornamented with fine, wavy crests more or less parallel to the free edge. Eight suboval to subquadrate loculi. The narrowest part of each partition half as wide as the adjacent loculus. Narrow rim around each loculus, distally slightly enlarged to form a lunate lip. Low submarginal ridge with numerous small papillae, separated from the part of the marginal surface bearing the loculi by a deep, narrow channel.

Surface finely granular. Anterior and posterior cardinal angles each about 115 degrees.

Dimensions of holotype, a right valve: Length 1.13 mm.; height 0.66 mm.; width (including bases of spurs) 0.40 mm.

Remarks: This species is one of those with a thick lateral rim on the frill, like *Abditoloculina obesivelata*, *Abditoloculina fundiornata*, and *Abditoloculina clavicavosa*. It can readily be separated from them by its number of loculi, which is eight instead of nine or ten. The lunate outer lip on each loculus is much narrower in *Abditoloculina palpebrata* than in *Abditoloculina obesivelata* or *Abditoloculina clavicavosa*.

The name of this species is derived from the Latin *palpebra*, f. ("an eyelid"), and refers to the shape of the lunate lip distal to each loculus.

Type: Holotype, a female right valve, no. 34666.

***Abditoloculina prominens* Kesling and Peterson,
new species**

Plate 1, figures 28-30, 48-49

Diagnosis: Large *Abditoloculina* species with each female valve having an almost flat frill without a lateral rim, a large linguiform L1, a low lobate L3, nine loculi, a low node-like anterior spur, and a large, horn-shaped, pointed posterior spur.

Female: Valve subpyriform in lateral view. Hinge line straight, anterior border subround, ventral and posteroventral borders gently subround, and posterior border sharply round. Frill extending beyond the free border by less than half its width. Positions of loculi not apparent in lateral view of the frill.

Trilobate; L1 a large, linguiform lobe extending well above the hinge line, L2 a large, vertically elongate knob-like lobe, and L3 a very low, small lobe extending

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slightly above the hinge line and ventrally confluent with the lateral surface. Posterior part of the valve very gently convex, low. S1 short and shallow, separating L1 and L2; S2 deep, sinuous, extending from dorsal to ventral border.

Anterior spur a low lobe ventral and slightly anterior to L2, almost the same size as L2. Posterior spur large, horn-shaped, its tip directed backward.

Frill flat, without rim of any kind. Nine subquadrate loculi. Partitions between the loculi with faint transverse grooves, their narrowest parts about half as wide as the loculi. Submarginal ridge low, with numerous small papillae, separated from the part of the marginal surface bearing the loculi by a narrow channel.

Surface finely granular, nearly smooth. Anterior and posterior cardinal angles about 115 and 130 degrees.

Dimensions of holotype, a left valve: Length 1.18 mm.; height 0.72 mm.; width (including spurs) 0.45 mm.

Remarks: This species is closely related to *Abditoloculina eminens*, from which it differs in having a deeper S2, a more pointed posterior spur, and nine instead of ten loculi.

The name of this species is derived from the Latin *prominens* ("jutting out"), and refers to the development of L1.

Types: Holotype, a female left valve, no. 34674. Paratype, a female left valve, no. 34675. Unfigured paratype, a female left valve, no. 34729.

Abditoloculina pumila Kesling and Peterson, new species

Plate 1, figures 7-9, 16-18

Diagnosis: Large *Abditoloculina* species with each female valve having an almost flat frill without a lateral rim, a small L1, a low lobate L3, and ten loculi.

Female: Valve subpyriform in lateral view. Hinge line straight, anterior and ventral borders subround, posteroventral border gently curved, and posterodorsal border round. Frill overhanging free edge by less than half its width.

Trilobate; L1 a low, small, inconspicuous swelling at the anterior corner, L2 a low, ovate knob, and L3 a low lobe projecting slightly above the hinge line. Posterior part of valve very weakly developed, only slightly convex. S1 very shallow, practically a semisulcus along the anterior edge of L2; S2 immediately anterior to midlength, rather deep, sinuous, extending from dorsal to ventral border.

Anterior spur a vertically elongate low lobe. Posterior spur massive, large, bluntly horn-shaped, curving outward and backward.

Frill from central anterior to posteroventral region, nearly flat. Ten subrectangular loculi set rather close

together. Each partition with faint cross grooves, its narrowest part about one-third as wide as the adjacent loculus. Low submarginal ridge with small papillae, separated from the part of the marginal surface bearing the loculi by a narrow channel. Lateral surface finely granular.

Dimensions of holotype, a right valve: Length 1.11 mm.; height 0.67 mm. Width of paratype no. 34670 (including spurs) 0.44 mm.

Remarks: This species is similar to three other species from the Jeffersonville limestone; it can easily be identified by its ten loculi, as compared with eleven in *Abditoloculina cavimarginata*, nine in *Abditoloculina pusilla*, and eight in *Abditoloculina repanda*.

The name of this species is derived from the Latin *pumilus* ("dwarfish, diminutive"), and refers to the small size and development of L1.

Types: Holotype, a female right valve, no. 34669. Figured paratype, a female right valve, no. 34670. Unfigured paratype, a female left valve, no. 34730.

Abditoloculina pusilla Kesling and Peterson, new species

Plate 1, figures 35-38

Diagnosis: Large *Abditoloculina* species with each female valve having an almost flat frill without a lateral rim, a small L1, a low lobate L3, and nine loculi.

Female: Valve subelliptical to subpyriform in lateral view. Hinge line straight, anterior and ventral borders round, and posteroventral border curved. Posterior one-fourth of valve unknown.

Trilobate; L1 a low, inconspicuous swelling at the anterior corner, L2 an ovate knob, and L3 a low lobe extending slightly above the hinge line. S1 a shallow groove, practically a semisulcus along the anterior edge of L2; S2 long, sinuous, very narrow between the spurs.

Anterior spur a vertically elongate lobe. Posterior spur large, its base subconical, its tip broken off and unknown.

Frill flat. Nine subrectangular loculi. Each partition between loculi more than half as wide as the adjacent loculus. Low submarginal ridge with faint papillae, separated from the part of the marginal surface with the loculi by a very narrow channel. Lateral surface smooth to finely granular.

Dimensions of holotype, an incomplete right valve: Height 0.63 mm.; width (including incomplete spur) 0.37 mm. Estimated length about 1.00 mm.

Remarks: *Abditoloculina pusilla* resembles *Abditoloculina prominens* in having nine loculi, a low L3, a node-like anterior spur, and a large, horn-shaped posterior spur; it can readily be distinguished by its very low L1, which

does not extend above the hinge line. It resembles *Abditoloculina repanda*, *Abditoloculina pumila*, and *Abditoloculina cavimarginata* in lateral outline, general lobation, and spurs, but can be separated from those species by the number of loculi (see Table 1).

The name of this species is derived from the Latin *pusillus* ("insignificant"), and refers to the development of L1.

Type: Holotype, an incomplete female right valve, no. 34676.

Abditoloculina repanda Kesling and Peterson,
new species

Plate 1, figures 22-24, 31-34

Diagnosis: Large *Abditoloculina* species with each female valve having an almost flat frill, a small L1, a low L3, and eight loculi.

Female: Valve elongate suboval in lateral view. Hinge line straight, anterior and posterior borders subround, and ventral border evenly curved. Frill overhanging free edge by about half its width.

Trilobate; L1 very low, inconspicuous, L2 an ovate knob, and L3 small, low, extending slightly above the hinge line. Posterior part of valve low, gently convex. S1 a shallow groove, S2 long and sinuous.

Anterior spur a lobe, slightly smaller than L2. Posterior spur large, horn-shaped, directed outward and backward.

Frill flat, without rim of any kind; a low, thin ridge extending from the rear end of the frill parallel to the posteroventral border, becoming indistinct near the posterior corner. Eight subquadrate to suboval loculi, each with a low, narrow rim. Narrowest part of each partition about half as wide as the adjacent loculus. Submarginal ridge with very small, low papillae. Channel narrow. Surface smooth to finely granular.

Dimensions of holotype, a right valve: Length 1.04 mm.; height 0.60.; width (including spurs) 0.41 mm.

Remarks: This species has only eight loculi, whereas *Abditoloculina pusilla*, *Abditoloculina pumila*, and *Abditoloculina cavimarginata*, which have similar lobation, have nine, ten, and eleven loculi, respectively. *Abditoloculina repanda* differs from *Abditoloculina palpebrata*, which also has eight loculi, in lacking a lateral rim on the frill and a lunate outer lip on each loculus, and in having a low lobe-like L3 and a very low L1.

The name of this species is derived from the Latin *repandus* ("bent backward"), and refers to the shape of the posterior spur.

Types: Holotype, a female right valve, no. 34672. Paratype, an incomplete female right valve, no. 34688.

Abditoloculina armata (Ulrich)

Plate 1, figures 68-69

Ctenobolbina armata ULRICH, 1900, pp. 181-182, pl. 8, fig. 6. — ELLIS AND MESSINA, 1952, unnumbered page, fig. 6.

Hollina armata (Ulrich). — ULRICH AND BASSLER, 1908, p. 315, pl. 42, fig. 14. — GRABAU AND SHIMER, 1910, p. 357, text-fig. 1660v. — BASSLER AND KELLETT, 1934, p. 329. — SWARTZ, 1936, p. 552, pl. 80, fig. 3b. — WARTHIN, 1937, card 71, fig. 6.

Abditoloculina armata (Ulrich). — KESLING, 1952, p. 767.

Diagnosis: Large *Abditoloculina* species with each male valve having a small L1 not extending above the hinge line, a knob-like L2, a bulbous L3 larger than L2, spurs compressed laterally, the anterior spur with a short conical spine along its posterior edge, the posterior spur large but not extending below the free edge, anterior branch of the velate ridge terminating on the ventral edge of the anterior spur with an enlargement, and posterior branch of the velate ridge extending from below the front spur to the posterior part of the valve.

Remarks: Swartz (1936, p. 552) has suggested that *Abditoloculina armata* is a dimorph of *Abditoloculina cavimarginata*. We are not certain which *Abditoloculina* female is the dimorph of *Abditoloculina armata*. It seems best to maintain *Abditoloculina armata* as a separate species until such time as the dimorphism can be proved.

All *Abditoloculina* males have certain features in common, such as two velate spurs and a divided velate ridge, the anterior branch terminating on the anterior spur and the posterior branch extending from below the anterior spur to the posteroventral or posterior region. They vary in the lobation, the shape of the spurs, and the nature of the rear terminus of the anterior branch of the velate ridge. The posterior spurs of *Abditoloculina armata* and several unnamed males are compared in Table 2. We do not have enough specimens to determine whether or not the differences noted among these males are significant.

Illustrated specimen: Topotype, a male right valve, no. 34652.

Unnamed *Abditoloculina* males

Several males of this genus were found which differ from *Abditoloculina armata*. They are grouped into four types, here called simply A, B, C, and D. The females to which they should be assigned are not known. Additional specimens should be studied before specific assignments are attempted.

The males of many hollinid ostracods can be readily determined to be dimorphs of a particular species for which the female is known, by the similarities in general shape of valve, lobation, and ornamentation between males and females. In this case, the solution is complicated by the close affinities of females of different species. The females of *Abditoloculina fundiornata*, *Abditoloculina clavicavosa*, *Abditoloculina obesivelata*, and

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Abditoloculina palpebrata, for example, have very similar lobation. Their outstanding differences are in the loculi and frill, dimorphic structures which are not present in the male.

TABLE 2
COMPARISON OF POSTERIOR SPURS IN MALE VALVES
OF *Abditoloculina* FROM THE
JEFFERSONVILLE LIMESTONE

Shape of spur	Spur extending below free edge	Spur terminating above free edge
Base bulbous, tip with tubercle		Type B
Subconical or horn-shaped, not compressed	Type C	Type A
Broad, laterally compressed	Type D	<i>A. armata</i>

In addition, the males are in several stages of development, or instars. It is difficult, in a small collection, to decide which specimens are adult and can therefore be compared directly with the females. It would seem, on the basis of the illustrated specimens, that lobation changes considerably during ontogeny. Many specimens of each species would be required to work out the ontogenetic series satisfactorily.

Type A (pl. 1, figs. 50-51): Only one specimen of this type was discovered. Valve elongate elliptical. Hinge line straight, anterior and posterior borders subround, and ventral border gently curved. L1 a low lobe with a posterodorsal small tubercle projecting above the hinge line, L2 a knob, and L3 knob-like and about the same size as L2. A small node anteroventral to L1 but behind the anterior border. S1 short, narrow; S2 deep, sinuous. Anterior spur somewhat compressed. Posterior spur horn-shaped, its apex pointing more outward than backward.

This type resembles type B, but has a more conical than bulbous posterior spur, L3 about the same size as L2 instead of smaller, and the tubercle on the rear edge of the anterior spur small instead of large and conspicuous. The illustrated specimen is an immature(?) left valve, no. 34681 (length 0.86 mm.; height 0.47 mm.; width 0.34 mm.).

Type B (pl. 1, figs. 52-55): Similar to type A. L1 low, without a posterodorsal tubercle, its dorsal border slightly above the hinge line and round; L2 an ovate knob; L3 smaller than L2, round, relatively low. A small lobe below and anterior to L1, about the same size as L1. Spurs with bulbous bases. Anterior spur with a prominent tubercle on its rear border. Posterior spur with a conspicuous, posteriorly directed tubercle. This type is distinguished from others by its bulbous spurs. The illustrated specimens are a left valve, no. 34682 (length 0.91 mm.; height 0.47 mm.; width 0.28 mm.), and an incomplete right valve, no. 34683.

Type C (pl. 1, figs. 62-63, 66-67): The larger valve found is subelliptical to subpyriform in lateral view. L1 a lobe with a conspicuous tubercle extending above the hinge line, L2 a vertically elongate knob, and L3 large, bulbous, extending above the hinge line. Node anteroventral to L1 located behind the anterior border. Spurs large. Anterior spur with a tubercle on its rear edge and a ventral projection marking the rear terminus of the anterior branch of the velate ridge. Posterior spur horn-shaped, strongly curved in both lateral and ventral views. The smaller specimen has L3 much smaller than L2, and the posterior spur terminating just above the free edge, but agrees with the larger specimen in other features.

This type differs from *Abditoloculina armata* and from type A and type B in having the posterior spur extending below the free edge. Its posterior spur is nearly round in cross section, and the node below L1 is behind the anterior border, in contrast to type D, in which the posterior spur is laterally compressed and the node below L1 projects forward. The illustrated specimens are a large right valve, no. 34684 (length 1.03 mm.; height, including spurs, 0.61 mm.; width 0.42 mm.), and a small right valve, no. 34685 (length 0.94 mm.).

Type D (pl. 1, figs. 60-61, 64-65): Similar to type C except that the node below L1 projects forward and extends beyond the rest of the anterior border, the spurs are compressed, the anterior spur projects farther laterally, and the posterior spur is wider and less curved. The smaller specimen has L3 about the same size as L2, and its posterior spur does not extend below the free edge. The illustrated specimens are a large right valve, no. 34686 (length 1.06 mm.; height 0.61 mm.; width 0.41 mm.), and a small right valve, no. 34687 (length 0.96 mm.).

Genus *Adelphobolbina* Stover, 1956

Type species: *Ctenobolbina papillosa* Ulrich, 1891, p. 186, pl. 15, fig. 8a-c, by designation of Stover, 1956, p. 1103.

Diagnosis: Hollinid genus with each valve essentially bilobate, having a large L1 and a very large L3 joined to a ventral lobe to form an exceptionally well developed U-shaped ridge around the deep S2; L2 partly distinguishable in some species, but invariably joined to L1; typically strongly papillose on the lobes and the posterior part of the valve; prominent, long frill in both dimorphs, separated from the marginal or submarginal ridge by a wide channel; female with a slightly incurved frill, in many species little different from the flat or slightly flared frill of the male.

Adelphobolbina papillosa (Ulrich) Plate 2, figures 25-30

Ctenobolbina papillosa ULRICH, 1891, p. 186, pl. 15, fig. 8a-c. — RAYMOND, 1904, p. 174. — ULRICH AND BASSLER, 1908, p. 310, pl. 40, figs. 21-22. — BASSLER AND KELLETT, 1934, p. 254. — CORYELL AND MALKIN, 1936, p. 3, text-fig. 8. —

SWARTZ, 1936, pl. 80, fig. 1f-g. — WARTHIN, 1937, card 68, fig. 8a-c. — ELLIS AND MESSINA, 1952, unnumbered page, fig. 8a-c. — KESLING AND TABOR, 1953, p. 88, pl. 3, figs. 16-17.

?*Ctenobolina papillosa* Ulrich. — WARTHIN, 1937, card 68, fig. A. *Adelphobolina papillosa* (Ulrich). — STOVER, 1956, pp. 1103-1104.

Diagnosis: *Adelphobolina* species with each valve having numerous large, spine-like papillae and very small, inconspicuous papillae on all of the lateral surface except the frill and the deep part of S2, frill wide and smooth, and L2 completely fused with L1.

Illustrated specimens: Topotypes, two male right valves, nos. 28093 and 34653, and a male left valve, no. 34651.

Genus *Ctenoloculina* Bassler, 1941

Type species: *Tetradella cicatricosa* Warthin, 1934, p. 209, pl. 1, figs. 4-6, by designation of Bassler, 1941, pp. 22-23.

Diagnosis: Hollinid genus with each valve distinctly quadrilobate, having a D-shaped L4 and vertical ridges for L1, L2, and L3; sulci deep; lobes ornate in known species; each male with velate spurs on the first three lobes; each female with six loculi and no spurs.

Ctenoloculina exocha Kesling and Peterson, new species

Plate 2, figures 8-13, 17-19

Diagnosis: *Ctenoloculina* species with each valve having the first three lobes projecting well above the hinge line and terminating with sharply pointed, posteriorly directed tips, set at an angle of about 80 degrees to the hinge line, and wider than the sulci, all lobes ornamented with low papillae and surrounded by narrow rims, and L4 D-shaped and twice as wide as L2, extending above the hinge line; male with ventral spurs on L1, L2, and L3, the spur on L1 pointing forward, on L2 pointing downward, and on L3 pointing backward, L1 concave anteriorly; female with a wide frill, overhanging the free edge by most of its width, confluent with L1, L2, and L3, and ornamented with slightly smaller papillae than the lobes, six round loculi each with a rim distally expanded as a lunate lip, and S1 and S2 ventrally wide, truncated by the frill and bearing two convexities marking the positions of the second and fourth loculi.

Male: Valve subelliptical in lateral view. Hinge line straight, anterior border round, ventral border gently curved, and posterior border curved.

Quadrilobate; L1, L2, and L3 slightly wider than sulci, nearly vertical, dorsally extending well above the hinge line, with sharply pointed, posteriorly directed tips, ventrally projecting below the free edge as spurs; L4 subrectangular to D-shaped, twice as broad as L2 or L3, projecting slightly but distinctly above the hinge line. All lobes ornamented with closely spaced small papillae and bounded on all sides by small rims. L1 the smallest

of the four lobes, crescent-shaped, concave anteriorly, its spur extending forward beyond the anteroventral part of the free edge. L2 nearly straight, forming an angle of about 80 degrees with the dorsal border. L3 long, parallel to L2, slightly constricted in its middle, its spur directed posteroventrally. All sulci deep, with nearly vertical sides, extending from the dorsal to the ventral border; average width of each sulcus slightly less than that of L2 or L3.

Anterior and posterior cardinal angles about 95 degrees each. Sulci and marginal surface smooth. Row of small, discrete submarginal papillae midway between the spurs and the free edge.

Dimensions of holotype, a left valve: Length 1.03 mm.; height 0.59 mm.; width 0.21 mm.

Female: Lobation similar to that of male except for frill. Frill from anteroventral end of L1 to pointed terminus behind S3, strongly convex anteriorly below its confluence with L1, with rim and ornamentation similar to those of the lobes but somewhat smaller, strongly overhanging the free edge by almost its full width. S1 and S2 with semicircular ventral ends next to the frill. Each sulcus with a low round node in its ventral part, that of S1 marking the second loculus, that of S2 the fourth loculus, and that of S3 the sixth and last loculus. Six round loculi, overhung by the frill, each surrounded by a rim, very narrow except in its thickened, lunate, lip-like distal part. Rims of adjacent loculi tangent.

Dimensions of allotype, a left valve: Length 1.07 mm.; height 0.76.; width 0.21 mm.; length exclusive of frill 0.97 mm.; height exclusive of lobes and frill 0.51 mm.

Remarks: This species is similar to *Ctenoloculina elongata* Stewart (1950, pp. 659-660, pl. 85, figs. 22-23) in having the lobes pointed and projecting well above the hinge line, but differs in having narrower sulci and wider lobes.

The name of this species is derived from the Greek *εξοχος* ("projecting, lofty"), and refers to the dorsal projections of L1, L2, and L3 above the hinge line.

Types: Holotype, a male left valve, no. 34644. Allotype, a female left valve, no. 34645. Paratypes, two female right valves, nos. 34646 and 34647.

Ctenoloculina platyca Kesling and Peterson, new species

Plate 2, figures 14-16, 20-22

Diagnosis: *Ctenoloculina* species with each female valve having low, broad L1, L2, and L3, each about twice as wide as the sulci, ventrally confluent with the narrow frill, and dorsally round, with only L1 and L3 extending slightly above the hinge line; S1 straight, ventrally widened and truncate at the frill, S2 crooked, rather S-shaped, and S3 L-shaped, narrow and vertical through most of its length but with a sharp angle and posterior deflection against the rear part of the frill;

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L4 slightly wider than L3, D-shaped; six round loculi, each with a narrow rim; exteriors of second, fourth, and sixth loculi forming small convexities in the lower parts of S1, S2, and S3, respectively.

Female: Valve subelliptical in lateral view. Hinge line straight, anterior and posterior borders subround, and ventral border curved.

Quadrilobate, with broad, low lobes. L1, L2, and L3 each about twice as wide as the adjacent sulcus, ventrally confluent with the frill, and dorsally round; L1 straight, set at about 70 degrees to the hinge line, slightly constricted at its junction with the frill; L2 widest in its dorsal half, with a straight anterior edge at about 83 degrees to the hinge line, and a sinuous posterior edge, terminating dorsally slightly below and nearly tangent to the hinge line; L3 panduriform, constricted in its middle and at its junction with the frill, dorsally extending slightly above the hinge line. L4 D-shaped, a little wider than L3, dorsally extending very slightly above the hinge line. S1 narrow, straight, except ventrally wider and truncate at the frill; S2 crooked, S-shaped but with angular geniculations, ventrally wide and bluntly truncate at the frill; S3 long, narrow, and vertical, except at its ventral end, where it is slightly expanded and turned backward along the rear part of the frill.

Frill narrower than L1, arcuate, extending from its confluence with L1 to its posterior pointed terminus slightly posterior to S3, overhanging the free edge by only about half its width. Six round, equal loculi, each with a narrow rim; rims of adjacent loculi tangent. Center of posterior (sixth) loculus aligned with the posterior edge of L3, half the loculus being below L3 and the other half below S3. Low convexities formed in the lower parts of S1, S2, and S3 by the exteriors of the second, fourth, and sixth loculi, respectively.

Dimensions of holotype, a left valve: Length 0.99 mm.; height 0.63 mm.; width 0.21 mm.

Remarks: No males of this species have been found. *Ctenoloculina platyca* closely resembles *Ctenoloculina cicatricosa* (Warthin, 1934, p. 209, pl. 1, figs. 4-6), but has wider lobes and narrower sulci. *Ctenoloculina platyca* has lobes twice the width of sulci, whereas *Ctenoloculina cicatricosa* has lobes and sulci of about equal width. In addition, the angle formed by the hinge line and L2 in the left valve is about 83 degrees in *Ctenoloculina platyca* and about 75 degrees in *Ctenoloculina cicatricosa*, the posterior loculus is slightly more posterior in *Ctenoloculina platyca*, and the lobes are somewhat lower in *Ctenoloculina platyca*.

The name of this species is derived from the Greek πλατυκος ("wide, broad"), and refers to the form of the lobes.

Types: Holotype, a female left valve, no. 34648. Paratype, another female left valve, no. 34649.

Genus *Flaccivelum* Kesling and Peterson, new genus

Type species: *Winchellatia teleutaea* Kesling and Tabor, 1952, p. 762, pl. 111, figs. 20-23, here designated.

Diagnosis: Hollinid genus with each valve trilobate but having L2 inconspicuous and partly fused with L1; S2 very long, sinuous; velate structure in female a broad incurved frill developed as a ventral continuation of the lateral surface; in male, a small velate ridge along the bend between the lateral and marginal surfaces.

Description: Each valve subpyriform in lateral view. L1 wide, low, confluent with ventral lobe. L2 vertically elongate, confluent with ventral lobe and, in some species, nearly confluent with L1. L3 a lobe extending above the hinge line, separated from the ventral lobe by a broad, very shallow depression only. Posterior part of the valve gently convex, not lobate. S1 shallow, scarcely developed in some species. S2 long, sinuous, conspicuous, extending from the hinge line to or nearly to the ventral border, broad and shallow in its ventral half. A posteroventral projection of the ventral lobe.

Male with a sharp bend between the lateral and marginal surfaces, with a small velate ridge or crest along the bend, beginning at the anterior corner and terminating at the tip of the posteroventral projection of the ventral lobe.

Female with a broad incurved frill, perfectly confluent with the rest of the lateral surface, edged by a narrow crest from the anterior corner to the posteroventral projection of the ventral lobe.

Remarks: In addition to *Flaccivelum informis* (Ulrich), described below, this genus includes *Flaccivelum teleutaeum* (Kesling and Tabor, 1952, p. 762, pl. 111, figs. 20-23), *Flaccivelum deminutum* (Kesling and Tabor, 1953, pp. 91-92, pl. 2, figs. 20-23), and *Flaccivelum deliquiatum* (Kesling and Tabor, 1953, pp. 90-91, pl. 2, figs. 24-29), all three of which were originally assigned to the genus *Winchellatia*. *Winchellatia* is a genus of Ordovician dimorphic ostracods described by Kay (1940, pp. 253-254), having L3 tangent to the hinge line but not projecting above it, and the velate structure in both dimorphs passing below the posteroventral projection of the ventral lobe instead of onto it. As suggested by Jaanusson (1957, p. 410), the greater development of L3 in the Devonian species distinguishes them from the Ordovician species that have been assigned to *Winchellatia*. Jaanusson assigns *Winchellatia* to the family Sigmoopsidae (1957, p. 378).

The name of this genus is derived from the Latin *flaccus* ("flaccid, flabby") and *velum*, n. ("frill"), and refers to the form of the frill in the female, which hangs downward from the lateral surface without any line of demarcation.

Flaccivelum informis (Ulrich)

Plate 2, figures 1-7

Ctenobolina informis ULRICH, 1891, p. 187, pl. 15, fig. 6a-c. — ELLIS AND MESSINA, 1952, unnumbered page, fig. 6a-c.

Hollina informis (Ulrich). — ULRICH AND BASSLER, 1908, p. 315. — BASSLER AND KELLETT, 1934, p. 330. — WARTHIN, 1937, card 75, fig. 6a-c.

Diagnosis: *Flaccivelum* species with each valve having L2 partly fused to L1, the dorsal edge of L1 round and extending above the hinge line, and the ventral half of S2 only a very shallow groove; as seen in ventral view, the frill of the female and the velete ridge of the male encroaching onto the posteroventral projection of the ventral lobe in an even, sweeping curve.

Male: Valve subpyriform in lateral view. Hinge line straight, anterior border round with radius little more than half the height, ventral border gently convex, and posterior border subround with radius nearly equal to the height. Posterior cardinal angle about 90 degrees.

L1 wide, low, dorsally round, extending above the hinge line, ventrally confluent with the anterior part of the ventral lobe. L2 an elongate lobe, partly joined to L1 and the ventral lobe. L3 lobate, extending above the hinge line, separated from the posterior part of the ventral lobe by a shallow, broad, inconspicuous groove. Posterior part of valve low, gently convex. Ventral lobe large, separated into two parts by the very shallow ventral half of S2. S1 narrow, shallow, confluent with S2 around the dorsal end of L2. S2 long and sinuous, deep and well defined in its dorsal half, shallow and inconspicuous in its ventral half. A prominent posteroventral projection of the ventral lobe, confluent with the rest of the lateral surface but forming an angular, pointed process directed backward.

Velate structure a very low ridge, practically a crest, along the sharp bend between the lateral and marginal surfaces, extending from the anterior corner to the posteroventral projection. As seen in anterior view, the dorsal two-thirds of the velate ridge are straight and parallel to the free edge, and the ventral one-third is set at a 45-degree angle away from the free edge. In ventral view, velate ridge curving evenly onto the posteroventral projection. A row of small submarginal papillae and a few irregularly scattered papillae of similar size immediately distal to it. Lateral surface smooth.

Dimensions of topotype no. 34641, a right valve: Length 1.24 mm.; height 0.71 mm.; width 0.36 mm.

Female: Frill strongly curved inward, confluent with the lateral surface, distally bearing a small crest. As seen in anterior view, the dorsal one-third of the frill is close to the free edge and parallel to it, the frill curving thence sharply outward; the ventral two-thirds of the frill are vertical, parallel to the dorsal one-third but distal from it. As seen in ventral view, the posterior part of the frill is curved outward onto the posteroventral projection. Submarginal papillae and a few adjacent papillae as in the male.

Dimensions of topotype no. 34642, a left valve: Length 1.38 mm.; height 0.91 mm.; width 0.38 mm.

Remarks: Although the holotype, U. S. National Museum, no. 41320, is worn and incomplete, we feel confident that it is conspecific with the specimens described and illustrated in this paper. This species closely resembles *Flaccivelum teleutaeum* (Kesling and Tabor), from which it differs in having L1 more lobate and extending above the hinge line, a smaller and more distinct L3, and the velete structure curving evenly onto the posteroventral projection in each dimorph instead of curving abruptly outward and recurving to form an "S."

Illustrated specimens: Topotypes, a male right valve, no. 34641; a male left valve, no. 34643; and a female left valve, no. 34642.

Genus *Hollina* Ulrich and Bassler, 1908

Type species: *Ctenobolbina insolens* Ulrich, 1900, pp. 182-183, pl. 8, figs. 10-11, by designation of Ulrich and Bassler, 1908, p. 315.

Diagnosis: Hollinid genus with each valve quadrilobate, having a lobe-like L1, a node-like L2, a bulbous L3, and a node- or lobe-like L4, all strongly developed; L3 partly joined to some form of ventral lobe in known species; male with two prominent spurs, each joined to some form of ventral lobe; female with a prominent frill, so strongly incurved that its distal edge lies in the plane of the contact margin.

Hollina insolens (Ulrich)

Plate 2, figures 31-35

Ctenobolbina insolens ULRICH, 1900, pp. 182-183, pl. 8, figs. 10-11. — ELLIS AND MESSINA, 1952, unnumbered page, figs. 10-11.

Hollina insolens (Ulrich). — ULRICH AND BASSLER, 1908, p. 315, pl. 42, figs. 8-9. — GRABAU AND SHIMER, 1910, p. 357, text-figs. 16631, m. — ULRICH AND BASSLER, 1923, text-fig. 20, no. 9. — KELLETT, 1929, pp. 199-200. — MOORE, 1929, p. 100. — BASSLER AND KELLETT, 1934, pp. 29, 330, text-fig. 11, no. 9. — WARTHIN, 1937, card 76, figs. 10-11. — SHIMER AND SHROCK, 1944, p. 671, pl. 282, figs. 11-12. — KESLING, 1951, pl. 2, fig. 7. — KESLING, 1952, p. 765, pl. 111, figs. 1-6. — POKORNÝ, 1954, text-fig. 530.

Diagnosis: *Hollina* species with each male valve thick, having a large vertically elongate lobe for L1, a small node-like knob for L2, a large bulb for L3, a vertically elongate knob for L4, a long sinuous S2 deeper in its dorsal half but extending to the ventral border, a very large ventral ridge partly joined to L3 and curving downward and forward to the bluntly round posterior spur, and a small ventral lobe partly joined to L1 and tapering downward and slightly backward to the small round tip of the anterior spur; female valve having the frill joined to L1, the ventral lobe, and the ventral ridge, an anteroventral cavity bounded by the frill, L1, and the ventral lobe and S2 terminated by the frill; all valves having closely spaced papillae on the lobes and large discrete submarginal papillae.

MIDDLE DEVONIAN OSTRACODS

Illustrated specimens: Topotypes, a male left valve, no. 34654, and an incomplete female right valve, no. 34655. Allotype, a male right valve, no. 27776.

***Hollina compressa* Kesling and Peterson, new species**

Plate 2, figures 36-38

Diagnosis: *Hollina* species with each valve thin and rather flat, having a wide, flat ventral lobe confluent with all lobes; the male with a wide, flat anterior spur partly confluent with the ventral lobe; female with a wide frill joined to L1 at its anterior end, to the ventral lobe at its middle and posterior inner edges, and with two deep cavities between the frill and the ventral lobe, one below L1 and the other below S2.

Male: Valve compressed, subpyriform in lateral view. Hinge line straight, anterior and posterior borders round, and ventral border gently curved except for convex projections of spurs.

Quadrilobate, with all lobes joined to a flat, long ventral lobe; L1 a flat lobe, L2 a flat node anteroventrally joined to the ventral lobe, L3 a laterally compressed bulb, and L4 a flat lobe. S1 and S2 dorsally confluent above L2; S1 very short, deep, directed anteroventrally; S2 deep, narrow and sloping posteroventrally in its dorsal half, with posterior and anteroventral extensions in its ventral half, giving it the shape of a short, inverted T, terminating at about the middle of the valve; S3 short, deep, curved, separating L3 and L4. A narrow, flat strip of valve along the posteroventral border and below the ventral lobe.

Anterior spur elliptical, elongate parallel to the anteroventral border, relatively flat and thin, joined to the ventral lobe only along part of its dorsal border, its anterodorsal edge bounded by a pit and its posterodorsal edge by a conspicuous groove; this spur more closely resembling a short frill than a spur, without a tip but with a round posteroventral end. Posterior spur broken from the holotype and paratype, the broken edge in the holotype showing a hollow, longitudinal slot (pl. 2, fig. 37); presumably, the posterior spur resembling the anterior, but unconfirmed. Surface finely papillose; where surface layer broken away, the inner layer showing somewhat coarser papillae; outer layer having a pebbly texture.

Dimensions of holotype, a right valve: Length 1.12 mm.; height 0.71 mm.; width 0.27 mm.

Female: Lobation like that of male. Frill extending from anterior corner to posteroventral part of valve, strongly incurved, its distal edge lying in the plane of the contact margin and the hinge. Frill confluent with ventral lobe anterodorsally, anteroventrally, and posteroventrally, but separated from it anteriorly by a deep, small, subtriangular pit and ventrally by a subquadrate deep pit.

Remarks: The allotype and only female valve was whole when found, but was firmly cemented to a bryozoan and nearly concealed by an overlying fragment of

another bryozoan. It was possible, by tilting the mass at a steep angle, to see most of the surface of the valve. As frequently happens with silicified specimens, and (seemingly) very frequently with those of new species, the female valve could be studied thoroughly and photographed only if the overlying material was removed, with the risk of damaging the specimen. It broke into many pieces. Several of the pieces were recovered and glued together in as nearly their proper places as could be determined. The result (pl. 2, fig. 38) is not very good, but it is the only female valve we have. The description is therefore based partly on what we remember the specimen originally to have been, rather than on what it is now.

This species can be compared with *Hollina insolens*, but it differs from that species in several features: It has a long ventral lobe extending nearly the full length of the valve and joined to L1, L2, and L4, all sulci limited to the dorsal half of the valve, and the valve very compressed. The spurs of the male, although hollow, are much thinner than those of any other species of *Hollina* known, and are of different shape.

The name of this species is derived from the Latin *compressus* ("compressed"), and refers to the form of the valve.

Types: Holotype, a male right valve, no. 34656. Allotype, a female right valve, incomplete and broken into several pieces, no. 34657. Unfigured paratype, an incomplete male left valve, no. 34717.

Genus *Hollinella* Coryell, 1928

Type species: *Hollinella dentata* Coryell, 1928, pp. 377-378, by original designation.

Diagnosis: Hollinid genus with each valve trilobate, having a lobe-like L1, a node-like L2, a bulbous L3, some kind of ventral lobe or lobes, and a low posterior part of the valve; S1 weakly developed, and L2 in some species joined to L1 (but retaining its identity), S2 much deeper, ventrally extending to the middle of the valve; dimorphism difficult to detect in some species, consisting of slight variation in curvature of the frill; the frill of the female more incurved than that of the male.

***Hollinella antespina* (Ulrich)**

Plate 2, figures 39-42

Ctenobolina? *antespina* ULRICH, 1891, p. 187, pl. 15, fig. 9a-c. -

ELLIS AND MESSINA, 1952, unnumbered page, fig. 9a-c.

Hollina antespina (Ulrich). - ULRICH AND BASSLER, 1908, p. 315.

Hollina antispinosa [sic] (Ulrich). - GRABAU AND SHIMER, 1910,

p. 357, text-fig. 1660y, y', y''.

Hollinella antespina (Ulrich). - KELLETT, 1929, p. 200. -

BASSLER AND KELLETT, 1934, p. 331.

Hollina hamiltonensis (Jones). - WARTHIN, 1937, card 74, fig. 9a-c.

?*Hollinella plauta* KESLING AND TABOR, 1953, pp. 86-87, pl. 1,

figs. 18-22.

Diagnosis: *Hollinella* species with each valve large, elongate subelliptical, ornamented with small, closely

spaced papillae and scattered larger papillae on the lateral surface; L1 broad and low, L2 vertically elongate and nearly joined to L1 along its anterior edge, being separated by a very shallow groove, L3 bulbous with a dorsal tubercle projecting above the hinge line, S1 short and shallow, S2 deep, with a sloping anteroventral extension below L2 and a rear extension under the anteroventral part of L3, a shallow groove along the posterior edge of L3, and a long ventral lobe from L1 and L2 to the posterior part of the valve, narrow and ridge-like below S2 and its extensions; frill well developed, smooth, extending from anterior corner to posteroventral region, its rear terminus thickened and spine-like.

Remarks: The holotype, U. S. National Museum, no. 41319, is somewhat worn and damaged in its anterior region, but appears to be conspecific with the specimens illustrated here. On the other hand, we seriously doubt that the specimens from the Genshaw formation of Michigan described as *Hollinella plauta* by Kesling and Tabor are conspecific with those from the Jeffersonville formation, but because we are uncertain, we list *Hollinella plauta* as a questioned synonym of *Hollinella antespinosa*. We note that, although the lobation and ornamentation are very similar, the ostracods from the Genshaw are rather smaller (1.44 mm. long, as compared with 1.60 mm. in a specimen from the Jeffersonville), the anteroventral extension of S2 below L2 is not as deep or long, the large papillae are not as high, and the frill is attached to the valve farther from the free edge. Additional specimens from both formations must be found and compared in order to determine whether or not these minor differences are specific.

Illustrated specimens: Topotypes, two right valves, nos. 34658 and 34659.

***Hollinella kolmodini* (Jones)**
Plate 2, figures 45, 48-49

Beyrichia kolmodini JONES, 1890, p. 538, pl. 20, fig. 6. — RAYMOND, 1904, p. 174. — ELLIS AND MESSINA, 1954, unnumbered page, fig. 6.

Beyrichia (?*Debranella*) *kalmodini* [sic] JONES. — ULRICH, 1891, p. 190, pl. 14, fig. 1a-c.

Hollina kolmodini (Jones). — ULRICH AND BASSLER, 1908, p. 315, pl. 42, figs. 5-7. — GRABAU AND SHIMER, 1910, p. 358, text-fig. 1665f-h. — MOORE, 1929, p. 100.

Hollinella kolmodini (Jones). — BASSLER AND KELLETT, 1934, p. 333. — WARTHIN, 1937, card 78, figs. 1a-c, 6. — SHIMER AND SHROCK, 1944, p. 669, pl. 282, figs. 1-3. — Not KESLING AND McMILLAN, 1951, p. 55, pl. 1, fig. 10.

Diagnosis: *Hollinella* species with each valve subovate, L1 and the anteroventral edge of L2 joined to a long prominent ventral lobe, L3 bulbous and ventrally truncate by a deep narrow groove separating it from the ventral lobe, S1 narrow, curved around the anterior border of L2, and S2 deep, curved around the posterior and ventral borders of L2, nearly reaching the ventral end of S1, dorsally confluent with S1; surface finely granulose, with several large, shallow punctae on the

lobes; frill thick, slightly convex, extending from corner to corner.

Remarks: The specimen from the Bell shale assigned to this species by Kesling and McMillan (1951, p. 55) is similar in lobation, but differs in having the frill terminated in the posteroventral region, S1 and S2 joined below L2, L3 spherical instead of ventrally truncate, and the lateral surface without scattered punctae. We do not believe it should be retained in *Hollinella kolmodini*.

Illustrated specimens: Topotypes, a right and a left valve, nos. 34663 and 34664.

***Hollinella spiculosa* (Ulrich)**

Ctenobolina spiculosa ULRICH, 1900, p. 181, pl. 8, fig. 5. — ELLIS AND MESSINA, 1952, unnumbered page, fig. 5.

Hollina spiculosa (Ulrich). — ULRICH AND BASSLER, 1908, p. 315, pl. 42, fig. 13. — GRABAU AND SHIMER, 1910, p. 357, text-fig. 1660u. — BASSLER AND KELLETT, 1934, p. 330. — SWARTZ, 1936, pl. 80, fig. 3d. — WARTHIN, 1937, card 77, fig. 5. — KESLING, 1951, pl. 3, fig. 7.

Diagnosis: *Hollinella* species with each valve conspicuous by its ornamentation of small, closely spaced sharp granules and scattered long, sharp spines; L1 terminating well above the hinge line as a spine; frill very wide, convex but not strongly incurved, projecting above the hinge line at its pointed anterodorsal tip and extending to the posteroventral region, not spinose like the lateral surface.

Remarks: No specimens of this unusual species were found in the present collection. Our knowledge of the species continues to be based on the holotype. In our opinion, the lack of an L4 and the lack of strong curvature of the frill exclude this species from *Hollina*; certainly, the lobation differs markedly from that in other species now assigned to *Hollina*. The male of this species is unknown. When a male is found, the nature of the dimorphism will probably show to what genus it belongs.

***Hollinella strumosa* Kesling and Peterson, new species**
Plate 2, figures 43-44, 46-47, 50-51

Diagnosis: *Hollinella* species with each female valve having a very long, vertical, ridge-like L1, a vertically elongate node for L2, a bulbous, very large L3 extending well above the hinge line, a slanting bulbous ventral lobe from below L2 to its acuminate end below L3, and a knob in the posteroventral region bearing a posterior large tubercle; S1 and S2 joined above and below L2, extending to the frill along the rear edge of L1; frill narrow, from the anterior corner to the posteroventral region, terminating below the edge of the posteroventral knob; surface smooth to finely granulose except the nearly flat posterior part of the valve, there bearing large scattered papillae.

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Female: Valve elongate subovate in lateral view. Hinge line straight, anterior border round, ventral and posteroventral borders gently curved, and posterior border curved. Posterior end of valve rather blunt in the holotype, convex in the paratype.

L1 long, vertical, ridge-like, dorsally round and extending above the hinge line, somewhat wider in its ventral half. L2 a prominent, vertically elongate node completely isolated by sulci. L3 exceptionally large and bulbous, dorsally spherical, ventrally truncate. Posterior part of valve convex. Ventral lobe very bulbous, subpyriform, slanting, its larger end lying below L2 and its acuminate end below L3. Posteroventral knob in the posteroventral region, tangent to the border, situated below the rear half of L3, bearing a large, prominent tubercle on its posterodistal surface. S1 long, deep, narrow, extending from the hinge line to the frill along the rear side of L1. S2 deep, confluent with S1 above and below L2, joined to a deep, narrow groove separating L3 from the ventral lobe.

Frill narrow, thick, tapering distally, its junction with the rest of the valve smooth and not marked in any way, extending parallel to the free edge from the anterior corner to the posteroventral region, there terminating proximal to the posteroventral knob. A row of distinct marginal (left valve) or submarginal (right valve) papillae. Lateral surface smooth to finely granular, except for scattered large papillae on the posterior part of the valve.

Dimensions of holotype, a left valve: Length 1.41 mm.; height 0.89 mm.; width 0.43 mm.

Male: One incomplete left valve was found that differed from the female valves. It shows signs of slight abrasion and wear, but we believe it shows the characters of the male, although perhaps somewhat modified.

Hinge line straight, anterior border round, and ventral border gently curved, as in the female. Posterior part of valve broken off and unknown. Lobes like those of the female. No velate structure whatever, except possibly the acutely rounded bend between the lateral and marginal surfaces.

Remarks: The genus *Hollinella* has been utilized by micropaleontologists for hollinid ostracods with many kinds of lobation and velate structures. Some species have frills from corner to corner (for example, *Hollinella kolmodini*, described and illustrated here), whereas most have the frill restricted to the anterior and ventral borders. Until now, no species has been described in which one dimorph has no velate structure; unless we regard the round edge of the bend as velate, the male of *Hollinella strumosa* described above shows no velate structure. We wish to point out that this specimen shows some signs of abrasion, although not to a great degree; it does not seem likely that the specimen originally had even a ridge as a velate structure. If additional male specimens are found which show the same features as those present in this one, the dimorphism and lobation

can be considered sufficiently different from those of other ostracods assigned to *Hollinella* to make this form a new genus.

The name of this species is derived from the Latin *strumosa*, f. ("a scrofulous tumor, goiter"), and refers to the unusually bulbous ventral lobe and large L3.

Types: Holotype, a female left valve, no. 34660. Allotype, an incomplete male left valve, no. 34661. Paratype, a female right valve, no. 34662. Unfigured paratype, an incomplete female right valve, no. 34726.

Genus *Subligaculum* Kesling and McMillan, 1951

Type species: *Subligaculum scrobiculatum* Kesling and McMillan, 1951, pp. 65-66, pl. 2, figs. 1-4; pl. 7, figs. 1-8, by original designation.

Diagnosis: Hollinid genus with each valve more or less quadrilobate, having L2 and L3 more prominent than L1 and L4; S2 the only deep sulcus, extending only from the hinge line to the middle of the valve; male with a posterior velate spur and a short anteroventral frill; female with a scalloped frill, the scallops forming cup-like structures but not loculi.

Subligaculum avitum Kesling and Peterson, new species

Plate 2, figures 23-24

Diagnosis: *Subligaculum* species very similar to the type species, but having each male valve with much lower and less distinct papillae, a conical spur, an unornamented frill, and no furrow from the posterocentral pit to the spur.

Male: Valve subquadrate to subelliptical in lateral view. Hinge line straight, anterior and posterior border bluntly subround, and ventral border gently curved.

L1 a lobe confluent with the ventral lobe, L2 a large knob extending to the hinge line, L3 a low knob posteriorly joined to L4, and L4 a curved lobe along the posterior border. Ventral lobe broad, prominent, extending from L1 to L4. S1 short, curved around the anterior border of L2; S2 deep, relatively narrow, curved around the posterior border of L2 but not quite joined to S1; S3 a deep pit, connected by a narrow furrow to the ventral part of S2. Velate structure developed as an anteroventral frill and a posteroventral spur. Frill narrow and flat, lying parallel to the plane of the contact margin and close to it. Spur subconical to conical, very prominent, projecting outward about as far as the frill. Surface of valve ornamented with very low, small, closely spaced papillae. Frill, spur, and sulci smooth to finely granular.

Dimensions of holotype, a right valve: Length 0.72 mm.; height 0.46 mm.; width 0.18 mm.

Remarks: This species appears to be a direct ancestor of *Subligaculum scrobiculatum* Kesling and McMillan, the type species. The two have about the same outline,

PLATE 1
All figures \times 30.

1-3 *Abditoloculina obesivelata* Kesling and Peterson, n. sp.
Lateral, ventral, and anteroventral views of holotype, no. 34665, a female right valve.

4-6 *Abditoloculina palpebrata* Kesling and Peterson, n. sp.
Lateral, ventral, and anteroventral views of holotype, no. 34666, a female right valve.

10-12 *Abditoloculina clavicavosa* Kesling and Peterson, n. sp.
Lateral, ventral, and anteroventral views of holotype, no. 34667, a female left valve.

13-15 *Abditoloculina fundiornata* Kesling and Peterson, n. sp.
Lateral, ventral, and anteroventral views of holotype, no. 34668, a female left valve.

7-9, 16-18 *Abditoloculina pumila* Kesling and Peterson, n. sp.
7-9, lateral, ventral, and anteroventral views of paratype, no. 34670, an almost complete female right valve; 16-18, lateral, ventral, and anteroventral views of holotype, no. 34669, a female right valve.

19-21 *Abditoloculina cavimarginata* (Ulrich)
Lateral, ventral, and anteroventral views of topotype, no. 34671, a female right valve.

22-24, 31-34 *Abditoloculina repanda* Kesling and Peterson, n. sp.
22-24, lateral, ventral, and anteroventral views of holotype, no. 34672, a female right valve; 31-34, lateral, ventral, anteroventral, and anterior views of paratype, no. 34688, a female right valve.

25-27 *Abditoloculina eminens* Kesling and Peterson, n. sp.
Lateral, ventral, and anteroventral views of holotype, no. 34673, a female left valve.

35-38 *Abditoloculina pusilla* Kesling and Peterson, n. sp.
Lateral, ventral, anteroventral, and anterior views of holotype, no. 34676, a female right valve.

28-30, 48-49 *Abditoloculina prominens* Kesling and Peterson, n. sp.
28-30, lateral, ventral, and anteroventral views of holotype, no. 34674, a female left valve; 48-49, lateral and ventral views of paratype, no. 34675, a female left valve.

39-41, 56-59 *Abditoloculina insolita* Kesling
39-41, lateral, ventral, and anteroventral views of topotype, no. 34677, a female left valve; 56-57, lateral and ventral views of allotype, no. 27779, a male right valve; 58-59, lateral and ventral views of topotype, no. 34678, a female left valve.

42-47 *Abditoloculina binodata* Kesling and Peterson, n. sp.
42-44, lateral, ventral, and anteroventral views of paratype, no. 34680, a female right valve; 45-47, lateral, ventral, and anteroventral views of holotype, no. 34679, a female left valve.

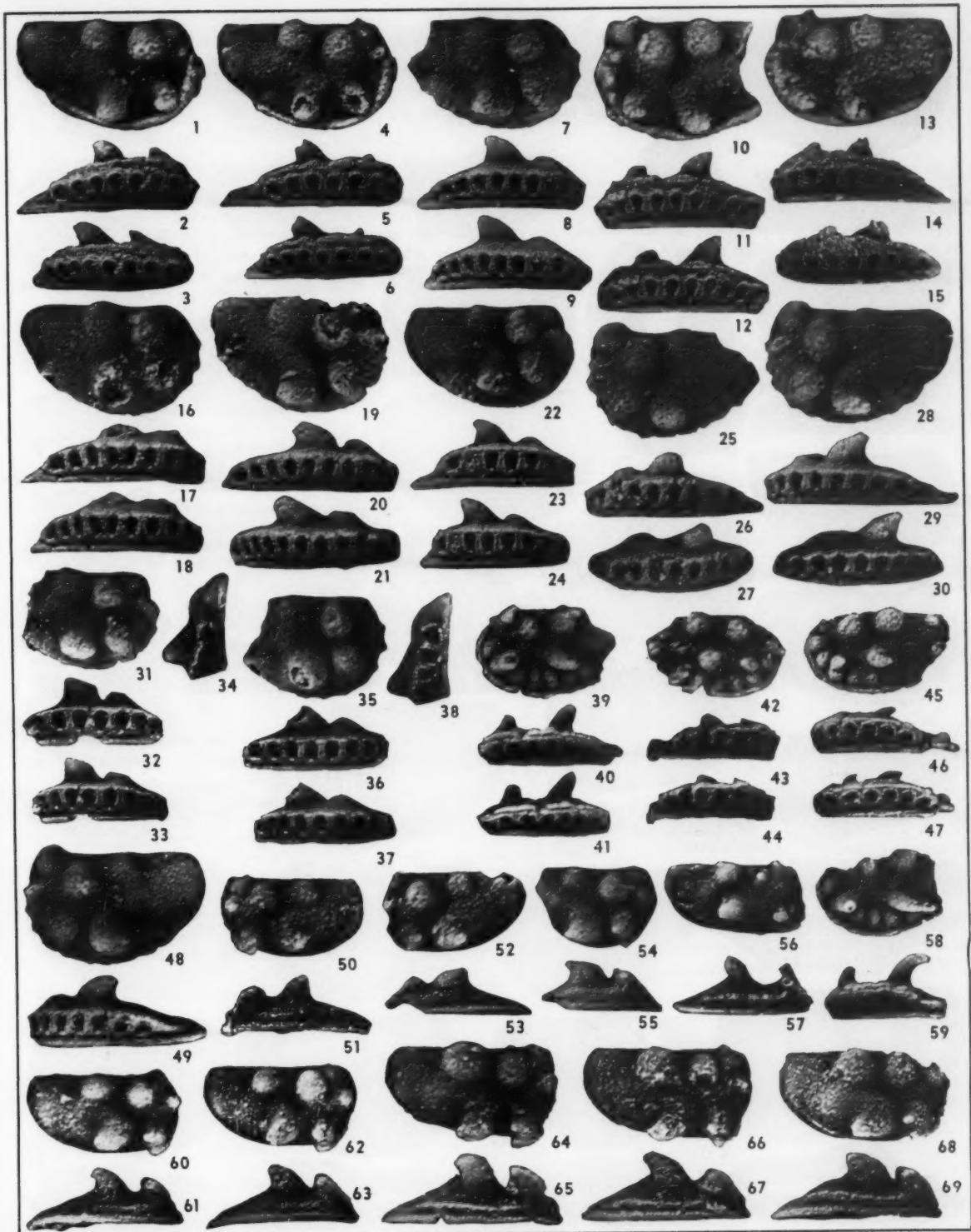
50-51 *Abditoloculina* male, type A
Lateral and ventral views of a male left valve, no. 34681.

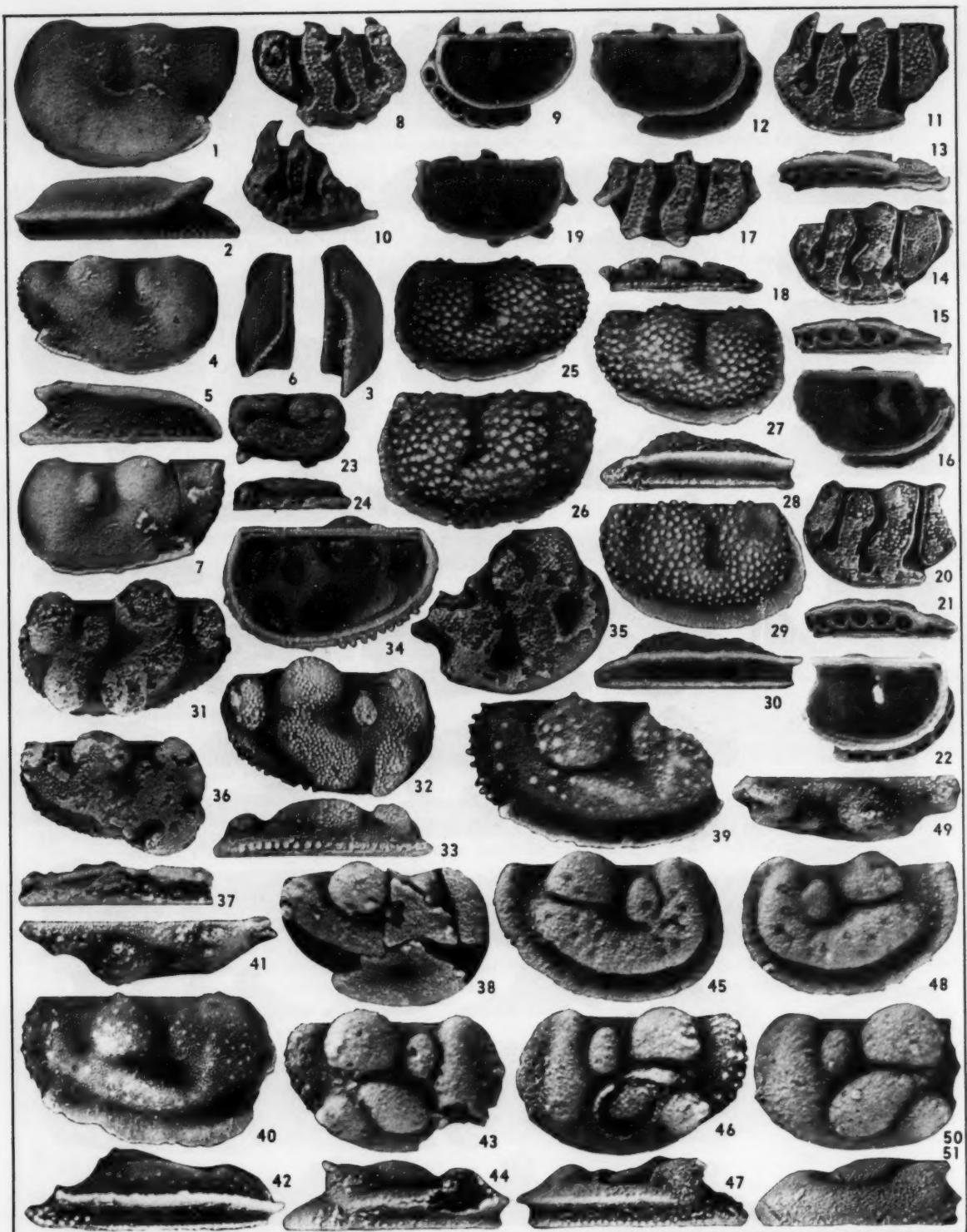
52-55 *Abditoloculina* male, type B
52-53, lateral and ventral views of an almost complete male left valve, no. 34682; 54-55, lateral and ventral views of an incomplete male right valve, no. 34683.

62-63, 66-67 *Abditoloculina* male, type C
62-63, lateral and ventral views of an immature male right valve, no. 34685; 66-67, lateral and ventral views of an adult male right valve, no. 34684.

60-61, 64-65 *Abditoloculina* male, type D
60-61, lateral and ventral views of an immature male right valve, no. 34687; 64-65, lateral and ventral views of an adult male right valve, no. 34686.

68-69 *Abditoloculina armata* (Ulrich)
Lateral and ventral views of topotype, no. 34652, a male right valve.





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PLATE 2
All figures \times 30.

1-7 *Flaccivelum informis* (Ulrich)

1-3, lateral, ventral, and anterior views of topotype, no. 34642, a female left valve; 4-6, lateral, ventral, and anterior views of topotype, no. 34641, a male right valve; 7, lateral view of topotype, no. 34643, a male left valve.

8-13, 17-19 *Ctenoloculina exocha* Kesling and Peterson, n. sp.

8-9, lateral and interior views of paratype, no. 34646, a female right valve; 10, lateral view of paratype, no. 34647, an incomplete female left valve; 11-13, lateral, interior, and ventral views of allotype, no. 34645, a female left valve; 17-19, lateral, ventral, and interior views of holotype, no. 34644, a male left valve.

14-16, 20-22 *Ctenoloculina platyca* Kesling and Peterson, n. sp.

14-16, lateral, ventral, and interior views of holotype, no. 34648, a female left valve; 20-22, lateral, ventral, and interior views of paratype, no. 34649, an almost complete female left valve.

23-24 *Subligaculum avitum* Kesling and Peterson, n. sp.

Lateral and ventral views of holotype, no. 34650, a male right valve.

25-30 *Adelphobolbina papillosa* (Ulrich)

25, lateral view of topotype, no. 34651, a male left valve; 26, lateral view of a male left valve; 27-28, lateral and ventral views of topotype, no. 34653, a male right valve; 29-30, lateral and ventral views of topotype, no. 28093, a male right valve.

31-35 *Hollina insolens* (Ulrich)

31, lateral view of topotype, no. 34654, a male left valve; 32-34, lateral, ventral, and interior views of allotype, UMMP no. 27776, a male right valve; 35, lateral view of topotype, no. 34655, an incomplete female right valve.

36-38 *Hollina compressa* Kesling and Peterson, n. sp.

36-37, lateral and ventral views of holotype, no. 34656, a male right valve; 38, lateral view of allotype, no. 34657, a female right valve.

39-42 *Hollinella antespinosa* (Ulrich)

39, lateral view of topotype, no. 34658, an incomplete male right valve; 40-42, lateral, dorsal, and ventral views of topotype, no. 34659, a male right valve.

43-44, 46-47, *Hollinella strumosa* Kesling and Peterson, n. sp.

50-51 43-44, lateral and ventral views of paratype, no. 34662, a female right valve; 46-47, lateral and ventral views of holotype, no. 34660, a female left valve; 50-51, lateral and ventral views of allotype, no. 34661, an incomplete male left valve.

45, 48-49 *Hollinella kolmodini* (Jones)

45, lateral view of topotype, no. 34663, a male right valve; 48-49, lateral and dorsal views of topotype, no. 34664, a male left valve.

sulcation, and velate structures, but *Subligaculum avitum* has much lower and less distinct papillae, its frill is unornamented, and it lacks a furrow connecting the posterior pit (S3) with the posteroventral border at the spur.

The name of this species is derived from the Latin *avitus* ("relating to a grandfather, ancestral"), and refers to its similarity to *Subligaculum scrobiculatum*, described previously from younger strata.

Type: Holotype, a male right valve, no. 34650.

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ABSTRACT: The genus *Nummoloculina* is revised to include miliolids with a quinqueloculine embryonic stage followed by a planispiral stage, and in which there is an apertural tooth. *Nummoloculina heimi* Bonet is emended, and *Planispirina schlumbergeri* Sidebottom, 1904, and *Planispirina striata* Sidebottom, 1904, are transferred into *Nummoloculina*. The contribution of miliolids to the porosity of Cretaceous oolitic limestones is discussed.

Revision of the genus *Nummoloculina* and emendation of *Nummoloculina heimi* Bonet

JAMES E. CONKIN AND BARBARA M. CONKIN

Department of Geology and Geography

University of Cincinnati

Cincinnati, Ohio

INTRODUCTION

Steinmann (1881, pp. 31-43) erected the genus *Nummoloculina* on the basis of material from the Pliocene of Italy, with *Biloculina contraria* d'Orbigny, 1846, as the type species. Until 1952, only two other species, *Nummoloculina regularis* Philipsson, 1887, from the Cretaceous of Austria, and *Nummoloculina irregularis* (d'Orbigny) [*Biloculina irregularis* d'Orbigny, 1839], from the Recent of the Falkland Islands, and one variety, *Nummoloculina contraria paradoxa* (Reuss) [*Biloculina contraria* var. *paradoxa* Reuss, 1867], from the Miocene of Poland, had been referred to *Nummoloculina*. There have been no sections published of either *Nummoloculina irregularis* or *Nummoloculina contraria paradoxa*, so that little can be said of the internal structure of these two forms. This is unfortunate inasmuch as the criteria now used for generic and specific differentiation are based on characters best seen in sections. Although *Nummoloculina contraria paradoxa* possesses the compression along a short axis that is characteristic of *Nummoloculina* (Reuss, 1867, p. 70, pl. 1, fig. 10a-b), the writers cannot, in the absence of sections, confidently refer this variety to *Nummoloculina*. *Nummoloculina irregularis* (d'Orbigny, 1839, p. 67, pl. 8, figs. 20-21) is even more doubtfully referred to *Nummoloculina*.

Bonet (1952, text-figs. 24-25, 27-28) figured a species of *Nummoloculina* from the El Abra miliolid member of the Albian-Cenomanian El Abra formation of northern Mexico. The writers (1956) reported *Nummoloculina* from Texas, Florida, and Louisiana, as well as from Mexico. In 1956 (pp.

402-406) Bonet described the El Abra species under the name *Nummoloculina heimi*. The writers were in the process of describing the El Abra species, which is the same as that in Texas, Florida, and Louisiana, when Bonet's description of *Nummoloculina heimi* appeared. The writers find Bonet's description and illustrations inadequate for defining the species; *Nummoloculina heimi* is therefore emended in this paper. The emendation is based upon excellently preserved specimens from the El Abra miliolid member of the El Abra formation of a locality near Antiguo Morelos, Tamaulipas, Mexico (locality no. 1), and upon other specimens obtained from surface and well samples from the Lower Cretaceous limestones of Texas and Florida (localities no. 2-6).

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GEOLOGIC RANGE AND STRATIGRAPHIC VALUE OF *NUMMOLOCULINA*

The writers (1956) formerly believed that *Nummoloculina* ranged in the Lower Cretaceous of the United States from the Sligo limestone through the

Devils River limestone. Since that time, the writers have recognized that their specimens of *Nummoloculina* found in well cuttings from the Sligo limestone interval were actually contaminations from the *Nummoloculina*-bearing Edwards limestone, far up in the bore hole; the writers therefore know of no specimens of *Nummoloculina* from the Sligo limestone. Until records of *Nummoloculina* are reported to the contrary, the Cretaceous range of the genus in the United States is herein determined to be from the Glen Rose limestone through the Devils River limestone (Trinity-Washita), or Albian according to the European stage terminology. Recent work by Bonet (1956, pp. 403, 404) has shown that *Nummoloculina heimi* is present in Mexico in limestones ranging in age from Albian through Cenomanian.

Nummoloculina-bearing limestones occur in the Washita (Devils River limestone) of southwestern Texas only where reef conditions continued in existence from the Fredericksburg into the Washita. The El Abra formation of northern Mexico was laid down under reef conditions which continued even through the Cenomanian. Inasmuch as beds bearing abundant *Nummoloculina* in North America are restricted to or associated with reef limestones of high calcium carbonate content, these beds can be thought of as a unit well set apart from the overlying basal Upper Cretaceous beds in the United States and set apart from overlying Turonian beds in Mexico. Although the world-wide geologic range of *Nummoloculina* has been determined as Lower Cretaceous to Recent (Conkin and Conkin, 1956, p. 891), only relatively rare specimens are known from strata younger than Albian-Cenomanian.

The ecologic and stratigraphic value of *Nummoloculina* was discussed by the writers (1956, pp. 894-896) and by Bonet (1956, pp. 404, 405), and will not be considered further except to state that there is evidence available to indicate that the Lower Cretaceous limestones of Texas can be differentiated primarily on the basis of miliolids. The writers are now working on such a division of the Lower Cretaceous limestones of Texas on the basis of miliolids.

METHODS

Many pieces of limestone from the El Abra miliolid member of the El Abra formation of Mexico (locality no. 1), from the Fredericksburg limestone of Florida (locality no. 5), and from the Devils River limestone (locality no. 2), the Edwards limestone (localities no. 3 and 4) and the Glen Rose limestone (locality no. 6) of Texas, were sectioned, polished,

and examined under the microscope. Thin sections were made of polished sections that exhibited good sagittal and axial sections of *Nummoloculina heimi*. Measurements were made from the thin sections. The text-figures accompanying the present paper were drawn from photomicrographs of thin sections.

In the writers' samples, the El Abra miliolid member is composed of innumerable excellently preserved specimens of *Nummoloculina heimi*. The sagittal and axial sections produced by random sectioning of the El Abra limestone are representative of the species. The writers' sample of the Devils River limestone contain innumerable specimens of *Nummoloculina heimi*, but they are not as well preserved as the El Abra specimens; the Edwards and Glen Rose limestones of Texas, and the Fredericksburg limestone of Florida do not contain specimens of *Nummoloculina heimi* in such great abundance as do the El Abra and Devils River limestones. Weathering has obscured the external features of the free specimens observed by the writers, and since it was not possible to extract unweathered specimens from the hard limestones, little can be said of the external features of *Nummoloculina heimi*.

LIST OF LOCALITIES

- 1) El Abra miliolid member (upper few feet) of the El Abra formation; road cut on Pan American Highway, 3 miles south of Antiguo Morelos, Tamaulipas, Mexico.
- 2) Devils River limestone, upper few feet, immediately below the Del Rio shale; 26.5 miles north of Del Rio on U.S. Highway 277, Val Verde County, Texas.
- 3) Edwards limestone; Travis Drillers, Inc.'s no. 1 L. R. Dillon, Jr., 12 miles northeast of Luling, Caldwell County, Texas. Core from 4628-4629 feet.
- 4) Edwards limestone; Stanolind's no. 2 O. S. Petty, Stuart City field, 0.5 miles east of Stuart City, LaSalle County, Texas. Core from 10,008-10,013 feet.
- 5) Fredericksburg limestone; Humble Oil & Refining Company's no. 1 (hole no. 2) Consolidated Naval Stores, in sec. 5, T. 45 S., R. 29 E., Hendry County, Florida. Core no. 4, from 9830-9853 feet, recovered 23 feet; sample from 9845-9846 feet.
- 6) Glen Rose limestone; Chenoweth and Harroun's (Pagenkoph) no. 1 Max Blum, Gas Ridge field, 15 miles west of San Antonio, Bexar County, Texas. Core from 2158-2176 feet.

REVISION OF NUMMOLOCULINA

MILIOLIDS, ÖLITES, AND POROSITY

Several genera of miliolids are known to occur in the Sligo, Glen Rose, Edwards, and Devils River limestones of Texas and in the Fredericksburg limestone of Florida, in deposits that were laid down in shoal, back-reef, and/or inter-reef environments. In many instances rolled and eroded miliolids form the centers of öölites, around which the calcareous layers have been formed. Such öölites have been observed in the Edwards, Glen Rose, and Sligo limestones of Texas and in the Fredericksburg limestone of Florida. The writers have observed similar öölites formed around *Millerella* in the Pennsylvanian Marble Falls limestone at Marble Falls, Texas, and around *Endothyra* and *Plectogyra* in the Mississippian limestones of Indiana, Kentucky, West Virginia, and New Mexico.

The possible contribution of miliolids to porosity in öölitic limestones is not yet appreciated. Such öölitic zones have long been recognized in the Glen Rose and Sligo (Pettet zones) limestones; however, the fact that a great, but indeterminable, number of the öölites were originally miliolids is here recorded for the first time. The nature of the matrix, and the action of dolomitization and solution, control the availability of theoretical interstitial porosity in öölitic limestones such as the Sligo (Pettet zones) and the Glen Rose. In some instances, nearly hollow öölites are formed around miliolid tests that have had their internal structure almost completely destroyed, especially in the inner portions, as a result of dolomitization and solution (see pl. 1, fig. 8). In addition, there may be a certain amount of porosity due to voids originally present in the empty tests of the miliolids.

SYSTEMATIC DESCRIPTIONS

Family MILIOLIDAE

Genus *Nummoloculina* Steinmann, emend. Conkin and Conkin

Biloculina d'ORBIGNY, 1846 (part), Foram. Foss. Vienne, p. 266, pl. 16, figs. 4-6.
Nummoloculina STEINMANN, 1881, Neues Jahrb. Min. Geol. Pal., vol. 1, p. 31, pl. 2, figs. 1-8.

Planispirina Seguenza. — BRADY, 1884 (part), Rept. Voy. Challenger, Zool., vol. 9, p. 195, pl. 11, figs. 10-11. — SIDEOTTOM, 1904, Manchester Lit. Philos. Soc., Mem. Proc., vol. 48, no. 5, pp. 20-21, pl. 5, figs. 9-14.

Not *Planispirina* SEGUENZA, 1880, R. Accad. Lincei Roma, Cl. Sci. Fis. Mat. Nat., Mem., p. 310, pl. 17, fig. 18, 18a.

Type species: *Biloculina contraria* d'Orbigny, 1846 (original designation, by Steinmann, 1881; Miocene, Austria).

In 1880 (p. 310) Seguenza erected the genus *Planispirina*, with *Planispirina communis* Seguenza, 1880, as the type

species. There has been much confusion regarding possible relationships between *Nummoloculina* and *Planispirina*. Brady (1884, pp. 192-196) placed *Nummoloculina* in synonymy with *Planispirina*; in recent years other writers, such as Glaessner (1945, p. 119), have considered that *Nummoloculina* may be congeneric with *Planispirina*. Cushman (1948, p. 179), however, clearly distinguished *Nummoloculina* from *Planispirina*, especially on the basis of the presence in *Nummoloculina* of an apertural tooth and quinqueloculine embryonic chambers.

The generic definition of *Nummoloculina* accepted by recent workers can be summarized as follows: A miliolid genus with quinqueloculine embryonic chambers that are followed by planispirally arranged whorls coiled about a short axis and divided into several chambers; aperture with a tooth. The accepted definition of *Planispirina* can be summarized as follows: An ophthalmidiid genus (and thus planispiral throughout) with a tendency to a rectilinear mode in the last chambers, giving a crosier-like form to the test; whorls divided into several chambers; aperture *Cornuspira*-like, with no tooth.

One of the main sources of confusion between the two genera *Nummoloculina* and *Planispirina* has been the failure of workers to recognize that *Nummoloculina* may have, in the megalospheric form, a completely planispiral test like that of *Planispirina*. Philippson (1887, p. 167) made the first observation concerning the planispiral nature of *Nummoloculina*, in his description of *Nummoloculina regularis*, which follows:

"Die von Steinmann beobachteten Embryonalwindungen, die nicht in einer Ebene liegen, fanden sich nicht vor; stets beginnt das Gehäuse mit einer relativ großen kugeligen Anfangskammer (Megasphäre nach Munier-Chalmas et Schlumberger, Bull. Soc. Géol. France, 3^e sér., t. XIII, p. 276). An einem Exemplar fand sich die von denselben Forschern als 'Polymorphismus initial' und zwar als 'Etat initial triloculaire' bei *Idalina antiqua* beschriebene Erscheinung vor (loc. cit., p. 296), indem die auf die Megasphäre folgenden ersten Windungen in verschiedenen Ebenen angeordnet sind, so daß der Horizontal-schnitt (Fig. 7) diese ersten Umgänge mehr oder weniger quer durchschneidet, während die folgenden regelmäßig in der Ebene ihrer Spirale getroffen sind. Dieser Polymorphismus kann nicht mit den von Steinmann geschilderten Embryonalwindungen verwechselt werden, welche an Stelle der Megalosphäre liegen, während sich diese letztere in unserem Falle wohl erhalten im Innern jener ersten *Triloculina*-ähnlichen Windungen zeigt."

Subsequent workers have overlooked Philippson's important observations on the planispiral nature of *Nummoloculina regularis*. However, the fact that *Nummoloculina regularis* is not completely planispiral in all members of the population studied by Philippson is shown by at least one of Philippson's type specimens, which was described by Philippson as containing milioline embryonic chambers (probably very early quinqueloculine chambers, initiating the quinqueloculine pattern). The writers independently arrived at

TABLE 1
MEASUREMENTS OF *Nummoloculina heimi* FROM THE EL ABRA Miliolid MEMBER OF THE EL ABRA LIMESTONE, LOCALITY NO. 1

Specimen	Form	Height in mm.	Diam. of pro- loculus in mm.	No. of quinque- loculine chambers	No. of whorls	Septa per whorl (number in parentheses is number of septa inferred for incomplete final whorl)						
						1st	2nd	3rd	4th	5th	6th	7th
1	micro.	0.70	0.033	4-5	3	6	7	10				
2 (text-fig. 6)	micro.	0.83	0.053	4	3½	6	8	10	7 (11)			
3 (text-fig. 7; pl. 1, fig. 2)	micro.?	1.00	0.026	2	4	4	5	6	8			
4	micro.	1.03	0.053	6	3½	5	10	12	11 (15)			
5 (text-fig. 5; pl. 1, fig. 3)	micro.	1.33	0.030	3	5½	6	9	9	11	15	2 (16)	
6	micro.	1.50	0.027	6	4½	4	7	10	11	6 (12)		
7	megalo.	0.53	0.078	8	1½	3	2 (4)					
8	megalo.	0.80	0.073	10	2½	3	5	2 (5)				
9	megalo.	0.83	0.079	10	2½	2	4	4 (6)				
10 (text-fig. 4)	megalo.	0.86	0.093	0	4	3	3	5	7			
11 (text-fig. 3)	megalo.	0.93	0.068	7	3	4	5	6				
12	megalo.	0.93	0.066	5	3½	2	2	4	3 (6)			
13 (text-fig. 2; pl. 1, fig. 5)	megalo.	1.03	0.093	5	3½	3	5	4	2 (8)			
14	megalo.	1.43	0.079	4	5½	2	4	4	6	7	4 (10)	
15 (text-fig. 1; pl. 1, fig. 1)	megalo.	1.53	0.093	7	5½	2	4	4	6	7	7 (10)	
16	megalo.?	1.83	?	4?	6½	?	5	6	7	10	10	15?
17 (text-fig. 8; pl. 1, fig. 4)	megalo.	1.00	0.073	10	3							
18	megalo.	1.23	0.103	6	4							
19 (text-fig. 9; pl. 1, fig. 6)	megalo.	1.26	0.073	?	6							
20	megalo.	1.43	0.073	9	4½							
21	?	2.06	?	?	7							

(Axial sections, septa not seen)

the fact that *Nummoloculina* (as represented by *Nummoloculina heimi*) may possess a completely planispiral test as a result of skipping the early quinqueloculine stage of development in the megalospheric form (see Tables 1-3, 5). This phenomenon also occurs in *Spiroloculina* (Cushman, 1948, p. 179).

As the writers interpret and emend the genus, *Nummoloculina* includes miliolids having quinqueloculine embryonic chambers (although these chambers may be absent in the megalospheric form), followed by planispiral whorls divided into chambers; the apertural tooth may be of different shapes in different species, and may even be bifid. The generic character that invariably distinguishes *Nummoloculina* from *Planispirina* is the presence of an apertural tooth in *Nummoloculina* and the absence of an apertural tooth in *Planispirina*.

In view of the generic definitions of *Planispirina* and *Nummoloculina* as here emended, the figures of *Planispirina schlumbergeri* Sidebottom, 1904 (p. 20, pl. 5, figs. 9-11) and of *Planispirina striata* Sidebottom, 1904 (p. 21, pl. 5, figs. 12-14) demonstrate clearly that these two species must be removed from *Planispirina* and must be placed in *Nummoloculina*. *Nummoloculina schlumbergeri* possesses milioline embryonic chambers and a bifid apertural tooth. *Nummoloculina striata* possesses a planispiral or nearly planispiral test and has a broad flat tooth in the aperture.

Nummoloculina heimi Bonet, emend.

Conkin and Conkin

Plate 1, figs. 1-10; text-figures 1-25

Nummoloculina sp., LEUPOLD, 1941, in HEIM, Eclogae Geol. Helv., vol. 33, no. 2, p. 324, text-fig. 5.

Nummoloculina sp., BONET, 1952, Asoc. Mexicana Geol. Petr., Bol., vol. 4, no. 5-6, p. 181, text-figs. 24-25, 27-28.

Nummoloculina sp., CONKIN AND CONKIN, 1956, Amer. Assoc. Petr. Geol. Bull., vol. 40, no. 5, p. 890, text-fig. 3.

Nummoloculina heimi BONET, 1956, Asoc. Mexicana Geol. Petr., Bol., vol. 8, no. 7-8, pp. 402-406, pls. 3-4.

Bonet's description of *Nummoloculina heimi* is as follows:

"Descripción. — Concha discoidea, de unas 900-1000 micras de diámetro, ligeramente bicóncava, con una anchura cerca del borde de unas 200 a 350 micras. Paredes muy gruesas, de espesores desigual (30 a 90 micras en distintas partes del mismo individuo). Los grandes ejemplares de cerca de 1 mm. de diámetro, en corte sagital muestran de 4 a 6 vueltas de espira además de las cámaras centrales. La última vuelta de espira tiene alrededor de 10 cámaras; los ejemplares pequeños, de tamaño mitad, presentan cuatro vueltas de espira y solamente 4-6 cámaras en la vuelta terminal; cámaras cónicas, alargadas con su extremo proximal estrechado y el terminal bruscamente truncado, de tal manera que la pared espiral presenta aspecto de rueda dentada. No se han observado los caracteres aperturales, pues a pesar de ser una especie abundantísima y muy frecuente todos los ejemplares conocidos se conservan en calizas compactas."

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TABLE 2
MEASUREMENTS OF *Nummoloculina heimi* FROM THE DEVILS RIVER LIMESTONE, LOCALITY NO. 2

Specimen	Form	Height in mm.	Diam. of pro- loculus in mm.	No. of quinque- loculine chambers	No. of whorls	Septa per whorl (number in parentheses is number of septa inferred for incomplete final whorl)						
						1st	2nd	3rd	4th	5th	6th	7th
22	micro.	0.53	0.026	8	1	4						
23	micro.	0.56	0.039	6	2½	4	7	?				
24	micro.	0.93	0.039	4?	3½	4	7	10	7 (14)			
25 (text-fig. 12; pl. 1, fig. 7)	micro.	1.33	0.039	5	4	5	7	9	11			
26	micro.	1.60	0.033	?	4?	?	9	12	15			
27	?	2.16	?	?	6 plus	?	?	12?	12?	15?	20?	
28	megal.	1.20	0.080	0	4½	1	4	7	8	4 (9)		
29	megal.	1.32	0.070	0	5½	0	3	5	6	8	2 (8)	
30 (text-fig. 10)	megal.	1.88	0.065	0	6½	1	3	6	7	8	9	6 (12)
31 (text-fig. 13)	?	1.33	?	?	5							
32	micro.	1.33	0.053	0	6							
33	megal.	?	0.112	?	?							
34 (text-fig. 11)	megal.	1.86	0.110	0	7							

(Axial sections, septa not seen)

Variación. — En una misma población pueden observarse muchas variaciones de detalle de tal manera que resulta difícil encontrar dos ejemplares exactamente iguales; esta variación real se acentúa aparentemente al considerar la variedad de aspectos que resultan de la distinta orientación de los planos de sección. No obstante, todos los individuos presentan una semejanza general de modo que no hay dificultad en su identificación. Algunos ejemplares de forma irregular parecen haber sufrido un crecimiento desigual a causa del contacto con otros individuos. Ya se ha apuntado la existencia de dos formas que difieren, entre otras cosas, en el tamaño; ignoramos cuál puede ser su significación taxonómica y biológica."

In his description, Bonet did not recognize megalospheric and microspheric forms, nor did he realize the planispiral nature of *Nummoloculina heimi* in the megalospheric form. Although Bonet's plates show *Nummoloculina heimi* as it often appears in randomly oriented sections of the El Abra limestone, the specimens figured are inadequate for revealing essential details of the nature of the species.

Bonet evidently neglected to figure or designate a holotype for *Nummoloculina heimi*. The writers can only assume that the two plates given by Bonet (1956, pls. 3-4) contain many syntypes. Inasmuch as neither of these plates illustrates complete axial or sagittal sections of specimens, nor do all the individuals together supply satisfactory information on which to base the specific concept of *Nummoloculina heimi*, the writers are basing their description and emendation of *Nummoloculina heimi* on their own hypotypes, many of which are deposited in various institutions in the United States and other countries. These hypotypes must form the basis of the present definition of *Nummoloculina heimi*, although they are secondary types. The writers do not feel disposed to choose one of Bonet's figured specimens as a lectotype. Any subsequent type designation is left to the discretion of the original author. The main

objective in emending *Nummoloculina heimi* is to show the true nature of the species and to establish its definition on a firm morphologic basis.

Emended description: Test free, biconcave to biconvex discoidal. Greatest thickness about one-quarter to one-half the height; height of largest measured specimen 2.16 mm.; height of smallest measured specimen 0.43 mm. Test consists of a proloculus, which measures from 0.026 to 0.053 mm. in the microspheric form and 0.056 to 0.112 mm. in the megalospheric form, followed by from one to ten more or less precisely arranged quinqueloculine embryonic chambers (which may be absent in the megalospheric form), and then followed by as many as seven somewhat involute, compressed planispiral whorls coiled at an angle to the axis of the quinqueloculine chambers, and divided by short septa into several chambers (as few as one to four chambers in the innermost whorl of megalospheric forms, but as many as sixteen and perhaps twenty chambers in the outer whorl of microspheric forms). Aperture, as observed in thin or polished sections, appears to be a low arch with a small, rather stocky tooth; the apertural tooth and former apertural teeth can be seen clearly in sagittal sections, but are rarely seen in axial sections.

Microspheric and megalospheric forms are readily distinguished on the basis of the size of the proloculus, and also by the fact that the microspheric form has up to five times as many chambers (usually, however, about twice as many chambers) per planispiral whorl as the megalospheric form, especially in the outer whorls (see Table 4). The greater number of chambers per whorl in the microspheric form gives these chambers a much less elongate appearance in sagittal section than the chambers of the megalospheric form (compare text-figs. 1 and 5). Furthermore, only the megalospheric form may possess a completely planispiral test.

TABLE 3
MEASUREMENTS OF *Nummoloculina heimi* FROM THE EDWARDS LIMESTONE (LOCALITIES NO. 3 AND 4),
FREDERICKSBURG LIMESTONE (LOCALITY 5) AND GLEN ROSE LIMESTONE (LOCALITY 6)

Loc.	Specimen	Form	Height in mm.	Diam. of proloculus in mm.	No. of quinque- loculine chambers	No. of whorls	Septa per whorl (number in parentheses is number of septa inferred for incomplete final whorl)				
							1st	2nd	3rd	4th	5th
3	35	micro.	0.76	0.046	8	1½	7	4 (8)			
	36 (text-fig. 16)	micro.	0.84	0.040	8	1½	6	6 (8)			
	37 (text-fig. 15)	megalo.	0.74	0.084	0	3	3	5	6		
	38	megalo.	1.03	0.079	1	4	3	5	6	8	
	39 (text-fig. 14; pl. 1, fig. 10)	megalo.	1.16	0.110	0	4½	1	5	6	7	2 (8)
	40	?	1.53	?	?	5					
	several axial sections		0.93– 1.16	0.026– 0.053	?	3–5½					
4	41 (text-fig. 17)	megalo.	0.73	0.066	3	3½	3	5	5	7 (9)	
5	42 (text-fig. 19; pl. 1, fig. 8)	megalo.	1.06	0.084	0	5	2	3	5	7	9
	43 (text-fig. 18)	megalo.	1.06	0.090	0	5	2	4	6	6	8
	44	?	1.20	?	?						
	45	?	1.33	?	?						
6	46 (text-fig. 24)	micro.	0.63	0.042	10	1	4				
	47 (text-fig. 25)	micro.	0.43	0.035	6	1½	4	4 (8)			
	48 (text-fig. 23)	micro.	0.73	0.046	4	2½	4	6	5 (10)		
	49 (text-fig. 22; pl. 1, fig. 9)	megalo.	0.43	0.056	7	1½	2	2 (4)			
	50 (text-fig. 21)	megalo.	0.50	0.070	4	2	2	3			
	51 (text-fig. 20)	megalo.	0.50	0.069	2	2½	3	3	4 (6)		
	a few larger specimens		0.93– 1.00								

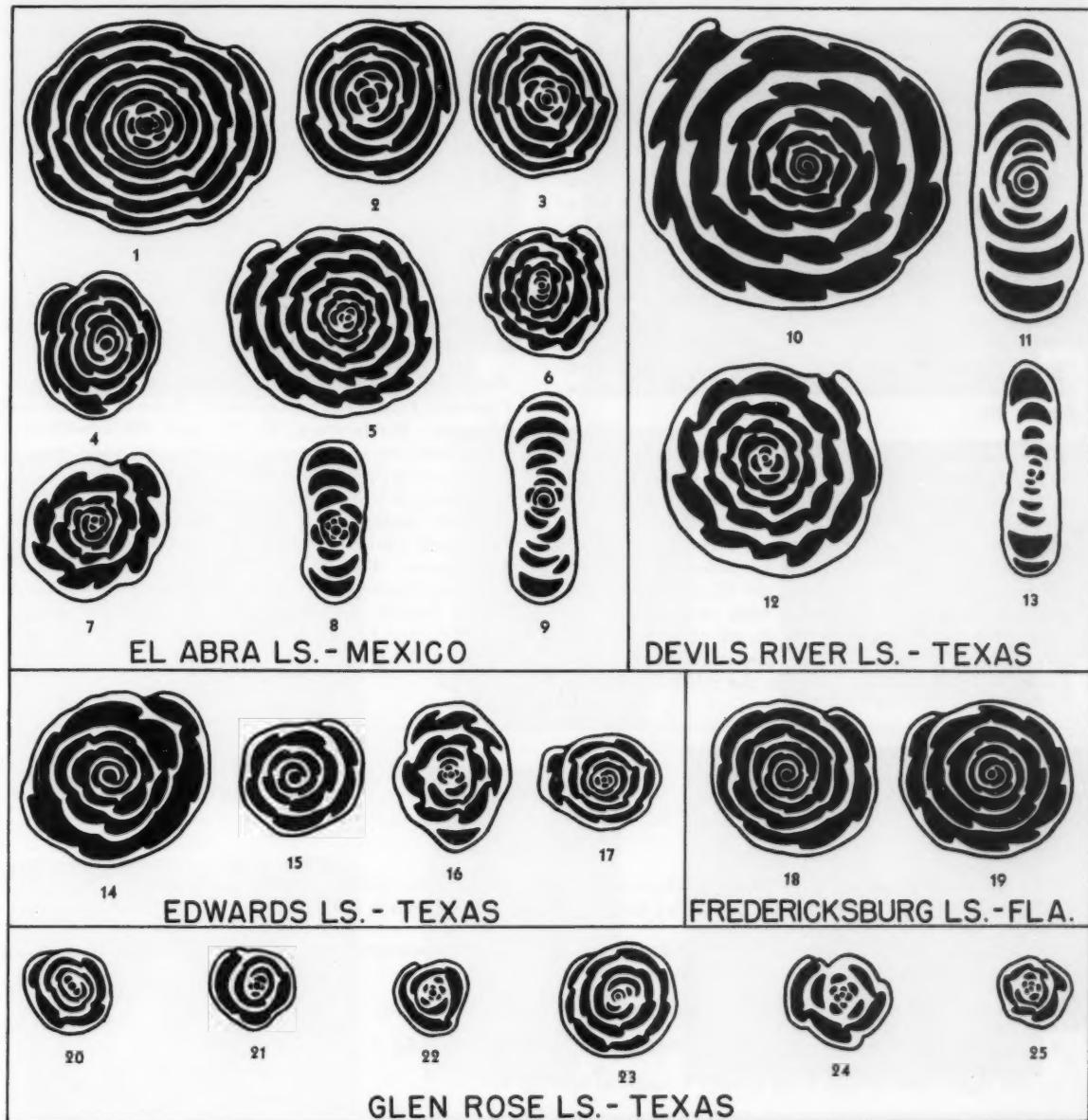
TABLE 4
RANGE IN MEASUREMENTS OF *Nummoloculina heimi*

Character	Microspheric forms	Megalospheric forms
Height	0.53–2.16 mm.	0.43–2.06 mm.
Diameter of proloculus	0.026–0.053 mm.	0.056–0.112 mm.
Septa per whorl		
1st whorl	4–7	0–4
2nd whorl	6–10	2–6
3rd whorl	9–12	4–8
4th whorl	11–15	6–9
5th whorl	12–15	7–10
6th whorl	12–16 (20?)	8–10

TABLE 5
COMPARISON OF THE SPECIES OF *Nummoloculina*

Species	Height	Quinque- loculine chambers	Whorls	Septa (or chambers)
<i>N. heimi</i>	0.43– 2.16 mm.	0–10	up to 7	8–16 (20?) in 6th whorl
<i>N. contraria</i>	about 2.0 mm.	?	5 or 6	6 chambers in 6th whorl
<i>N. regularis</i>	about 0.2– 0.3 mm.	0–3?	5½–10	3 in outer whorl
<i>N. schlum- bergeri</i>	1.44– 1.76 mm.	6 or more	3½	2 in inner, 3 in outer whorls
<i>N. striata</i>	1.0 mm.	2	4	2 in inner, 3 in outer whorls

REVISION OF *NUMMOLOCULINA*



EXPLANATION OF TEXT-FIGURES 1-25

Nummoloculina heimi Bonet, emend. Conkin and Conkin, all \times ca. 28; 1-4, sagittal sections of megalospheric forms: 4, a completely planispiral form; 5-6, sagittal sections of microspheric forms; 7, sagittal section of microspheric form showing less than the usual number of chambers per whorl; 8-9, axial sections: 9, showing a rather irregular embryonic portion similar to that in text-figure 11; 10, sagittal section of megalospheric form; 11, axial section of megalospheric form; 12, sagittal section of microspheric form; 13, axial section, walls thickened; 14-15, sagittal sections of megalospheric forms, planispiral throughout; 16, sagittal section of microspheric form; 17, sagittal section of megalospheric form; 18-19, sagittal sections of megalospheric forms, planispiral throughout; 20-22, sagittal sections of megalospheric forms: 21, showing an especially well developed apertural tooth; 23-25, sagittal sections of microspheric forms.

Measurements of *Nummoloculina heimi* are given in Tables 1-3. Table 4 gives the ranges of measurements of specimens studied for this paper.

Comparison: *Nummoloculina heimi* differs from all other species of *Nummoloculina* in the large number of chambers per whorl (see Table 5), but it has its closest affinities with *Nummoloculina contraria*.

Discussion: There is great variation in the number of quinqueloculine embryonic chambers following the proloculus in *Nummoloculina heimi* (see Tables 1-3); in some of the megalospheric forms of *Nummoloculina heimi* the quinqueloculine stage is completely absent. This absence would seem to place these forms in *Planispirina*, except for the presence of teeth in these forms and the fact that there are only one or two "quinqueloculine" chambers in some other specimens of *Nummoloculina heimi* (Table 3, specimen 38; text-figs. 7, 20).

Large individuals of *Nummoloculina heimi* consisting of six or even seven planispiral whorls, such as those shown in text-figures 1 and 10, are generally found only where there are abundant specimens present, as in the limestones with very high calcium carbonate content of the El Abra and Devils River formations. In an area of 36 sq. mm. in a thin section of the El Abra limestone, sixty specimens of *Nummoloculina heimi* were counted, of which fifty are small specimens, six are of medium size, and only four are large. Only a few large specimens of *Nummoloculina heimi* were found in the other limestones.

The Edwards limestone (containing frequent *Nummoloculina heimi*) and the Glen Rose limestone (containing rare *Nummoloculina heimi*) have a less pure calcium carbonate matrix, and the specimens of *Nummoloculina heimi* in these formations are not abundant; hence, large specimens are rare. Large specimens were noted occasionally in the Edwards and Glen Rose limestones, but unfortunately these individuals were not cut in such a way as to allow measurements other than their approximate height (see Table 3).

Text-figures 1-25 illustrate the variation seen in *Nummoloculina heimi*. Considered by themselves, the megalospheric forms shown in text-figures 10 and 22, for example, would not seem to belong to the same species; however, a gradation between these specimens is clearly seen in text-figures 14, 4 and 20.

Deposition of types: Fifteen hypotypes are deposited in the Cushman Foraminiferal Collection of the U. S. National Museum, Washington, D. C., nos. 626226-626240. Hypotypes are also deposited in the type collections of the following institutions: Bureau of Economic Geology, University of Texas, Austin, Texas, no. 20269; Department of Geology Museum, University of Cincinnati, Cincinnati, Ohio, no. 34531; Florida Geological Survey, Tallahassee, Florida, no. S-4642; Paleontological Research Institution, Ithaca, New York, nos. 25315-25316; Amt für Bodenforschung, Hannover, Germany, no. 2205; and Geological Department, British Museum (Natural History), London, England, nos. P 41688 and P 41689.

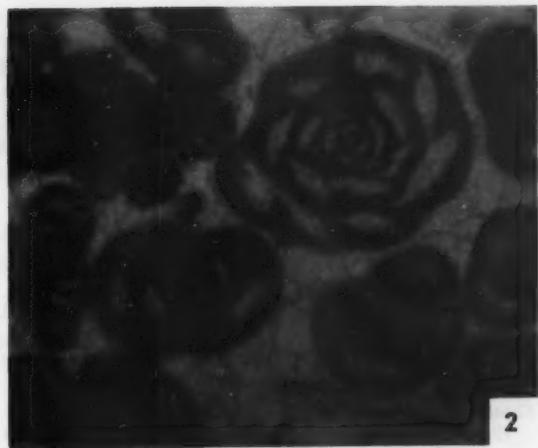
PLATE 1

All figures approximately \times 40 except where noted. All specimens of *Nummoloculina heimi* Bonet, emend. Conkin and Conkin. (Much more detail can be seen with a microscope than can be seen in these photomicrographs.)

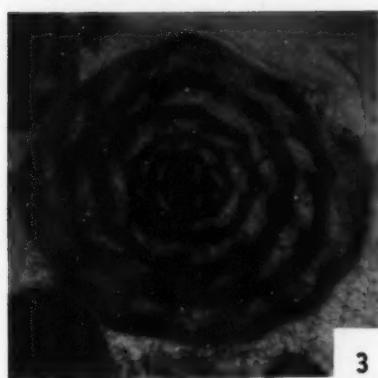
- 1 Sagittal section of megalospheric form from the El Abra miliolid limestone, locality 1 (same as text-fig. 1), showing clear calcite matrix and abundance of specimens.
- 2 Sagittal section of megalospheric form from locality 1 (same as text-fig. 7).
- 3 Sagittal section of microspheric form from locality 1 (same as text-fig. 5).
- 4 On right, axial section from locality 1 (same as text-fig. 8).
- 5 Sagittal section of megalospheric form from locality 1 (same as text-fig. 2).
- 6 Axial section from locality 1 (same as text-fig. 9).
- 7 Sagittal section of microspheric form from the Devils River limestone, locality 2 (same as text-fig. 12), showing relatively poor preservation as compared with the El Abra specimens.
- 8 Sagittal section of megalospheric form from the Fredericksburg limestone of Florida, locality 5 (same as text-fig. 19), showing oölites formed of miliolids.
- 9 Sagittal section of megalospheric form from the Glen Rose limestone, locality 6 (same as text-fig. 22).
- 10 Sagittal section of megalospheric form from the Edwards limestone, locality 3 (same as text-fig. 14), \times 27.



1



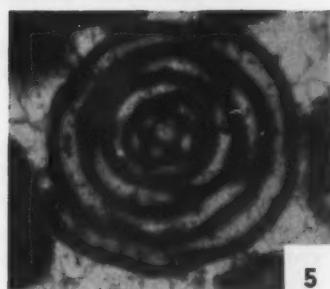
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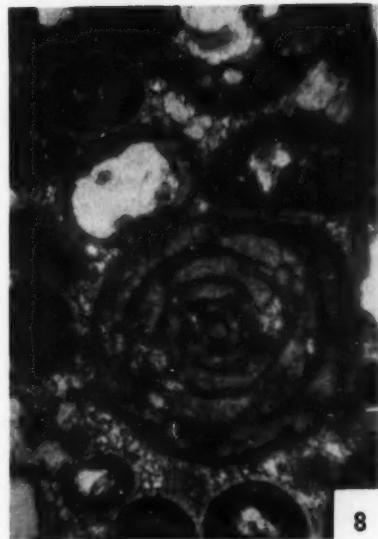
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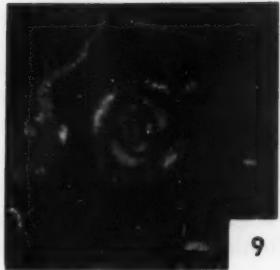
8



6



7



9



10

CONKIN AND CONKIN

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ABSTRACT: As an introduction to a study of the taxonomic status of dispersed spores of the Paleozoic, the author has compared spores from four Carboniferous lycopodiaceous cones with those described under *Sporae dispersae* by previous authors. The spores from the following cone species have been studied: *Lepidostrobus goldenbergi* Schimper, *Lepidostrobus variabilis* Lindley and Hutton, *Sigillariostrobus goldenbergi* Feistmantel, and *Selaginellites elongatus* Goldenberg, and it has been found that more than one cone species may produce microspores that are morphologically alike. The association of particular megaspore species with *Lepidostrobus goldenbergi* and *Lepidostrobus variabilis* is not considered conclusive proof of their having been produced in these cones.

Notes on the spores of four Carboniferous lycopods

J. SEN

Paleobotanical Department
Swedish Museum of Natural History, Stockholm, and
Botanical Laboratory
University College of Science, Calcutta

INTRODUCTION

The species concept for *Sporae dispersae* is a growing problem. It has been found that a spore species may be borne by different species of cones. In some cases this is obviously the result of aggregating too many species of spores under one specific name (based on morphological characters only). This fact has been taken into consideration in Potonié and Kremp's (1954, 1955, 1956a) new morphologic system of classification, in which many of the previously known spore species were dismembered. The value of this treatment is already evident in some cases, where some of the newly proposed spore species, made by splitting and reorganizing the old ones, are more definitely comparable with spores in some species of cone (Potonié and Kremp, 1956b). On the other hand, the fact that a single cone species may bear more than one spore species, other than heterospory, is also worthy of consideration. Furthermore, the question of the contamination of apparently "multisporous" cone species by foreign spores should always be considered especially in any problematic case. This problem has been discussed in detail by Chaloner (1953b). Perhaps the best possible way out of such anomalies is to study spores from known cones (including their holotypes, whenever possible), collected from different localities. It is clear that unless the limits of a spore species are determined, its taxonomic and stratigraphic value is limited.

The natural tendency in the study of *Sporae dispersae* is to approach as closely as possible the situation in

Quaternary pollen analysis, where spores and pollen contribute to the histories of their parent plants even in areas lacking in megafossils. In stratigraphy it is, of course, sometimes possible to deal with spores without knowing their natural affinities, but here also it is obviously of great value to obtain information on natural taxonomy.

Recently the natural affinities of several principal groups of dispersed megaspores and some microspores have been suggested and discussed with reference to the newly imposed limits on spore species (which perhaps also include natural species) (Potonié, 1954; Potonié and Kremp, 1954, 1955, 1956a, b). The recent contributions by Chaloner (1952, 1953a-c, 1954a, b) and others toward solving the problem of correlating dispersed spore species with those occurring in cones are valuable indications of progress in this direction. The present investigation is another in the series exploring the possibilities in the same field.

METHODS

Spores were separated from the megafossils with a mounted needle or by "cello tape" pulls, in the way described by Chaloner (1953b). They were subsequently macerated with potassium chlorate in nitric acid, followed by treatment in dilute ammonia in some cases, and finally mounted in sandarac. Some of them were also examined in dry condition with the help of reflected light.

SYSTEMATIC DESCRIPTIONS

Lepidostrobus goldenbergi Schimper
Plate 1, figure 1

(Synonymy in Jongmans, 1930, pp. 486-487; 1936, p. 1048.)

The cone compression is one of the originals (Schimper, 1870, pl. 61, fig. 3) upon which the species is based. It belongs to the Goldenberg Collection (from the Saar) of the Paleobotanical Department, Swedish Museum of Natural History, Stockholm.

Megaspore (pl. 1, figs. 4-6): *Bentzisporites margaritatus* Bhardwaj, which has also been described from the Sporae dispersae in the Saar coals (Bhardwaj, 1957, p. 107). Spore body subtriangular, 423μ - 518μ in diameter; small warts (or tubercles) on proximal surface, and often with a hump on each of the contact faces; triradiate ridges become low near the arcuate ridges, which flatten into a thin "cingulum."

I have also described isolated spores of this general type from the matrix of some shale specimens in the Goldenberg Collection (from the Saar), which are somewhat different from the typical *Bentzisporites margaritatus* (Sen, MS.), but the establishment of a new species on the basis of my previous finds was postponed in view of the small number of specimens available for examination. The spores of the *Bentzisporites* type are stated to be selaginelloid in nature (Potonié, 1954; Potonié and Kremp, 1954, 1956b), and in fact spores belonging to this genus have already been recovered from *Selaginellites elongatus* Goldenberg by Halle (1907) (also see the present paper). But its association with *Lepidostrobus goldenbergi* shows that a part of the genus *Bentzisporites* may occur also in other groups of lycopods. However, the situation no doubt deserves further scrutiny.

Microspore (pl. 1, fig. 7): *Lycospora parva* Kosanke (Kosanke, 1950, pp. 44-45), which has also been described from the Sporae dispersae in the Saar coals (Bhardwaj, 1957, p. 104). Spore body somewhat roundish to subtriangular in transverse plane, 23.1μ - 32μ in diameter, averaging 27.8μ ; trilete rays extend almost to a narrow flange ("cingulum"); exine minutely punctate, pale yellowish.

Lepidostrobus variabilis Lindley and Hutton also bears very similar microspores (see the present paper); the megaspores in the two cone species are, however, absolutely different. The only differences between the microspores borne by the two cone species are that they are mostly roundly triangular without body folds and with slightly greater average size and range of size in *Lepidostrobus goldenbergi*. The affinity of the *Lycospora* to the Lepidopeltales and related lycopods (e.g., Lepidophytales and Lepidodendraceae) has already been pointed out by Kosanke (1950), Potonié (1954), and Potonié and Kremp (1954, 1956b).

Lepidostrobus variabilis Lindley and Hutton
Plate 1, figure 2

(Synonymy in Jongmans, 1930, pp. 515-519; 1936, p. 1049.)

The cone compression was collected from Kamenný Újezd (about 128 km. south of Prague), Upper Carboniferous of Bohemia. For description of cone, see Simson-Scharold (1934, p. 7) and Hartung (1935, p. 73).

Megaspore (pl. 1, figs. 8-9): *Triletes triangulatus* Zerndt (see Dijkstra, 1955, p. 338, for description). The old species *Triletes triangulatus* has been split into several species under the newly established genus *Triangulatisporites* Potonié and Kremp, and the specimens under investigation are referable to *Triangulatisporites triangulatus* (Zerndt) Potonié and Kremp (Potonié and Kremp, 1954, p. 163; 1956a, pp. 128-131). Spore body subtriangular (to somewhat circular), 472μ - 526μ in diameter (excluding the subequatorial flange or "zona"); reticulae 14μ - 30μ on proximal face, and up to 72.6μ (sometimes up to 87.6μ) on distal face; triradiate ridges up to 53μ high; flange transparent, undulated, usually crenate, up to 60μ broad and up to 145μ broad opposite the triradiate ridges, where they pass into the flange.

Triletes triangulatus has previously been reported from *Selaginellites suissei* Zeiller (= *Lycopodites suissei* Zeiller, *Lycopodites ciliatus* Kidston) by Chaloner (1954b), and from a new species, *Selaginellites crassicinctus*, by Hoskins and Abbott (1956). According to Potonié and Kremp (1956b), the specimens dealt with by Chaloner belong to *Triangulatisporites triangulatus* (created out of the old species *Triletes triangulatus*), to which the specimens I have studied from *Lepidostrobus variabilis* should also be referred (as indicated previously). Similar specimens have also been previously studied by me from the matrix of shale in the Goldenberg Collection (from the Saar).

Unfortunately there is no other specimen of *Lepidostrobus variabilis* available to me for checking my findings. This is especially necessary because I was able to separate only a few isolated megaspores after repeated attempts. My present findings regarding the association of *Triangulatisporites triangulatus* with *Lepidostrobus variabilis* should therefore be considered essentially provisional. It is believed that spores of the *Triangulatisporites* type belong to the Selaginellales, which is also evident from previous records (Potonié, 1954; Potonié and Kremp, 1954, 1956b).

Microspore (pl. 1, fig. 10): Appears to be closely similar to *Lycospora parva* Kosanke, which I have separated from *Lepidostrobus goldenbergi* (for differences, etc., see above in the present paper). Spore body somewhat roundish to subtriangular in transverse plane, 24.5μ - 30μ (rarely up to 32μ) in diameter, averaging 26.2μ ; trilete rays extend almost to a narrow flange ("cingulum"); exine minutely punctate, sometimes with foldings on body, pale yellowish.

SPORES OF CARBONIFEROUS LYCOPODS

Sigillariostrobus goldenbergi Feistmantel

(Synonymy in Jongmans, 1932, pp. 985, 991, 995.)

Only megaspore preparations made from the cones collected from the Saar (Goldenberg Collection) and from the Mines-de-Marles, Sainte-Barbe, France, have been available for examination. Probably one of the slides was prepared from a cone also previously studied by Zeiller, who first referred to the general nature of megaspores in *Sigillariostrobus goldenbergi* (1884), which were subsequently generically identified by Potonié and Kremp (1956b, p. 71), probably from Zeiller's (1884, pl. 12, fig. 6a) semi-diagrammatic figure.

Megaspore (pl. 1, fig. 2; pl. 2, fig. 12): *Triletes mamillarius* Bartlett (see Dijkstra, 1955, p. 329; Dijkstra and van Vierssen Trip, 1946, pp. 28-31). The old species *Triletes mamillarius* has been split into several species under the recently emended genus *Tuberculatisporites* (Ibrahim) Potonié and Kremp, and the specimens under investigation are referable to *Tuberculatisporites subfuscus* (Wicher) Potonié and Kremp (Potonié and Kremp, 1955, p. 92). Spore body appears to be more or less circular (to subcircular), about 1452μ - 1718μ in diameter; triradiate system elevated, often sharply angular with open suture covering one-half to one-third of the spore radius; "coni" outside contact areas usually cylindrical (to somewhat circular with tubercle-like appearance rather than with sharp points), 28μ - 58.5μ long and often almost as broad, the most common size being about 37μ , larger "coni" away from the contact areas, irregularly and sparsely distributed.

The splitting of the old species *Triletes mamillarius* has been found necessary in the present study. Spores belonging to this broad species (*Triletes mamillarius*) were also recorded by Chaloner (1953c) from *Sigillariostrobus rhombibracteatus* Kidston emend. Chaloner, which are, however, distinct from the specimens examined by me (for details regarding the parentage of the spores in question, see Potonié and Kremp, 1956b, pp. 70-71).

Tuberculatisporites subfuscus was previously recorded from the Sporae dispersae in the Saar coals (Bhardwaj, 1957), from which at least one of the cones yielding some of the specimens under investigation was collected. None of the prepared slides contains any microspores.

Selaginellites elongatus Goldenberg Plate 1, figure 3

(Synonymy in Jongmans, 1930, p. 548; 1932, p. 710.)

The species, together with its megaspores (pl. 2, figs. 13-16) (no microspores were found), was described in detail by Halle (1907, pp. 10-14). The material belongs to the Goldenberg Collection of the Swedish Museum of Natural History, Stockholm.

There has been some comment regarding the proper assignment of the megaspores of *Selaginellites elongatus* within the classification of the Sporae dispersae (Potonié

1954; Potonié and Kremp, 1956b). In an attempt to assess the situation, I again separated megaspores from the material previously studied by Halle (1907). The minimum size (of the equatorial diameter) of my specimens (314.6μ - 401μ ; average 355.1μ , based on twelve spores) is definitely lower than that previously recorded for the recently created genus *Bentzisporites* Potonié and Kremp, (Potonié and Kremp, 1954, p. 161; 1956a, p. 124), to which my specimens (including those of Halle) undoubtedly belong (also see Potonié and Kremp, 1956b, p. 74, in this connection). They are also very small as compared with the spores measured by Halle (1907, p. 13) from the same material. Halle described spores about 450μ in size. Most of my specimens bear a hump on each of their contact faces (pl. 2, fig. 13), as in *Bentzisporites tricollinus* (Zerndt) Potonié and Kremp (previously *Triletes tricollinus* Zerndt), instead of holes as described by Halle (1907, p. 12). It is probable that the humps were destroyed in Halle's (1907) spores, leaving holes in their place. My spores, however, are smaller than those of *Bentzisporites tricollinus* (which are 340μ - 450μ in diameter, according to Bhardwaj, 1957, p. 106), and of the other comparable species, *Bentzisporites bentzii* (which are 350μ - 400μ in diameter, according to Potonié and Kremp, 1954, p. 161; 1956a, p. 124). My specimens are more closely comparable with *Bentzisporites bentzii*, as far as size and surface ornamentation (exclusive of the presence of a hump on each of the contact areas) are concerned (pl. 2, figs. 13-16). Actually, they are not strictly comparable with any known species of the genus *Bentzisporites*.

If my specimens are regarded as immature forms of those described by Halle (1907), which they probably are not, as some of them bear well-developed surface ornamentation and open trilete suture (pl. 2, figs. 14-16), the situation is also worthy of consideration. This problem can be overcome gradually by examining the spore content of a number of cones of the same species. For the present, I propose that the lower size-limit of the megaspores of *Selaginellites elongatus*, as described by Halle (1907), be considered to be about 310μ , without any definitely known comparable spore species among the Sporae dispersae assigned to the genus *Bentzisporites*.

I most gratefully acknowledge my indebtedness to Professor Olof H. Selling, of the Paleobotanical Department, Swedish Museum of Natural History, Stockholm, for his valuable help during the progress of this work.

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EXPLANATION OF PLATES

PLATE 1

Photographs by K. E. Samuelsson.

- 1 *Lepidostrobus goldenbergi* Schimper
One-half natural size. Goldenberg Collection, Swedish Museum of Natural History, Stockholm.
- 2 *Lepidostrobus variabilis* Lindley and Hutton
One-fourth natural size. Upper Carboniferous, Bohemia; Swedish Museum of Natural History, Stockholm.
- 3 *Selaginellites elongatus* Goldenberg
Natural size. Goldenberg Collection, Swedish Museum of Natural History, Stockholm.
- 4-6 cf. *Bentzisporites margaritatus* Bhardwaj, $\times 50$.
- 7 *Lycospora parva* Kosanke, $\times 500$.
- 8-9 *Triletes triangulatus* Zerndt (cf. *Triangulatisporites triangulatus* (Zerndt) Potonié and Kremp), $\times 50$.
- 10 cf. *Lycospora parva* Kosanke, $\times 50$.
- 11 *Triletes mamillarius* Bartlett (cf. *Tuberculatisporites subfuscus* (Wicher) Potonié and Kremp), $\times 50$.

PLATE 2

Photographs by K. E. Samuelsson.

- 12 *Triletes mamillarius* Bartlett (cf. *Tuberculatisporites subfuscus* (Wicher) Potonié and Kremp), $\times 50$.
- 13-16 *Bentzisporites* sp.
13-15, $\times 50$; 16, magnified view of specimen shown in fig. 15, $\times 500$, showing the characteristic perine.



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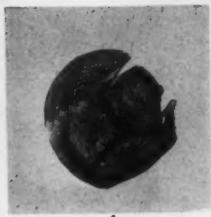
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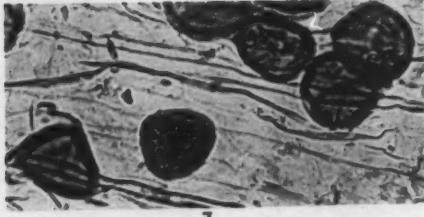
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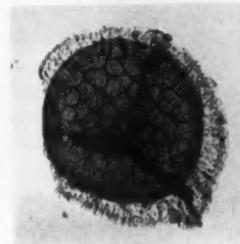
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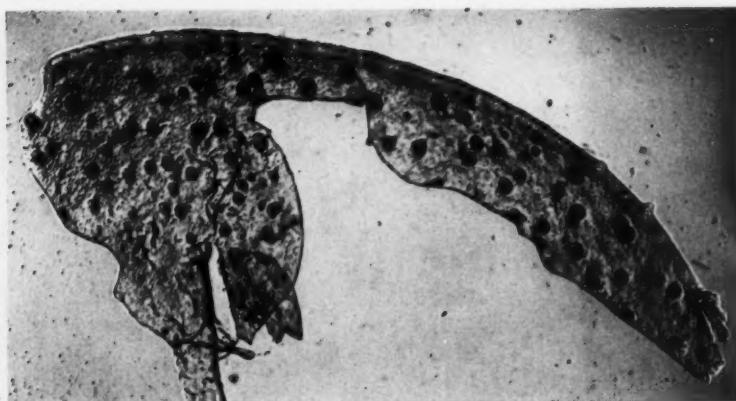
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ABSTRACT: *Conorbitoides*, *n. gen.*, *Ctenorbitoides*, *n. gen.*, and *Aktinorbitoides*, *n. gen.*, conical and stellate pseudorbitoid genera, are described from the late Upper Cretaceous of Cuba. These forms are associated with encrusting foraminifera which, together with Rhodophyta, play an important role as reef builders. A key to the genera of the Pseudorbitoididae is also presented.

New Pseudorbitoididae from the Upper Cretaceous of Cuba, with remarks on encrusting foraminifera

PAUL BRONNIMANN
Esso Standard Oil, S. A.
Havana

INTRODUCTION

In probably late Campanian or early Maestrichtian beds of reefal to fore-reefal facies there occur in Cuba, in addition to *Vaughanina* Palmer, three new pseudorbitoid genera, *Aktinorbitoides*, *n. gen.* (genotype *Aktinorbitoides browni*, *n. sp.*), *Ctenorbitoides*, *n. gen.* (genotype *Ctenorbitoides cardwelli*, *n. sp.*), and *Conorbitoides*, *n. gen.* (genotype *Conorbitoides cristalensis*, *n. sp.*). These new genera have been encountered in subsurface samples from Camagüey Province, Cuba, and *Ctenorbitoides cardwelli* has also been found in a surface sample from Habana Province, Cuba. A representative of *Aktinorbitoides* that is probably different from *Aktinorbitoides browni* is also reported from a surface sample from southern British Honduras. In the type material, the two conical forms, *Ctenorbitoides cardwelli* and *Conorbitoides cristalensis*, are associated. The stratigraphically slightly older stellate form, *Aktinorbitoides browni*, has not been found together with either of the conical pseudorbitoids. Two of the genera, *Aktinorbitoides* and *Ctenorbitoides*, are, as far as the internal organization is concerned, related to *Vaughanina* Palmer (Bronnimann, 1954). *Conorbitoides*, on the other hand, is a conical pseudorbitoid derived from *Sulcoperculina* Thalmann.

Two species of encrusting foraminifera are also described, *Acervulina cenomaniana* (Seguenza) and *Placopsisina* sp. ex gr. *cenomanica* d'Orbigny - *longa* Tappan, both of which intergrow in layers with

Archaeolithothamnium sp. and *Solenopora piai* Keijzer. Together with these Rhodophyta, they play an important role as reef builders in the late Upper Cretaceous of Cuba.

KEY TO THE GENERA OF THE PSEUDORBITOIDIDAE

The definition of a genus does not need to be, and often cannot be, restricted to a single character. In the early stages of a taxonomic study, an apparently satisfactory generic grouping may be achieved by the use of a single distinguishing feature. In the later stages, as the group of forms becomes better known, a single character is frequently no longer diagnostic. Additional features, usually of a more general nature than those used in the beginning, have to be introduced into the generic definitions, which then become more complex. The Globotruncanidae furnish a good example of this trend in taxonomic work (Bronnimann and Brown, 1956). In the Pseudorbitoididae, the genera already known have been defined on the basis of the elements of the equatorial layer alone. After having studied the conical and aktiniate pseudorbitoids, it is the writer's opinion that the overall shape of the test is also an important taxonomic criterion. It is of a more general nature than the internal structure of the equatorial layer, and can be used in the definition of taxa of higher than generic rank. The following key is therefore based on both of these criteria:

Test lenticular:

Outline aktiniate.

Outline circular:

Equatorial layer with annular walls

Equatorial layer without annular walls:

Neanic stage with radial rods:

Two sets of radial rods

More than two sets of radial rods

Neanic stage with radial plates:

Single set of radial plates, as a rule not interconnected laterally

Single set of radial plates, irregularly interconnected laterally, and with incipient radii and interradii

Test conical:

Apex pointed, neanic stage sulcoperculinoid

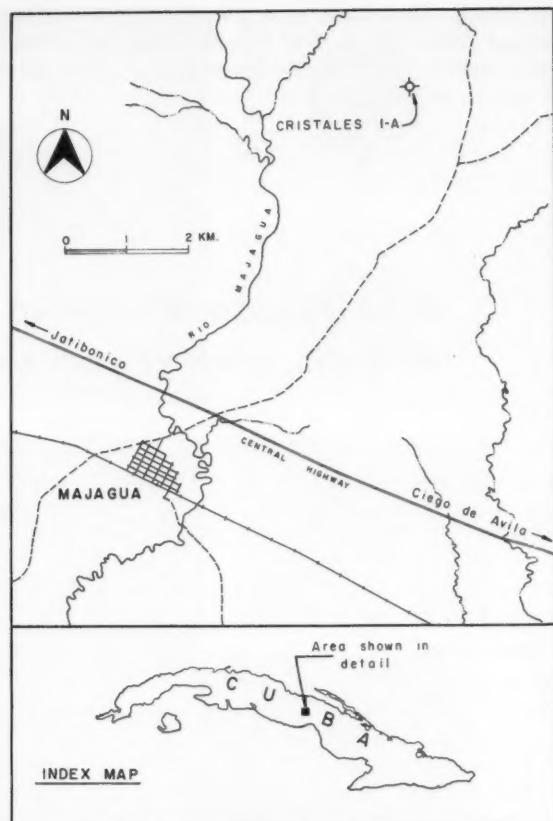
Apex comb-like, neanic stage vaughaninoid

ORIGIN OF MATERIAL

The new pseudorbitoids and encrusting foraminifera described here occur in a dark gray, hard fragmental limestone in two cores taken from 2789–2808 feet and from 2808–2838 feet in Cuban American Cristales well no. 1A. The well is situated in central Camagüey Province, Cuba, about 4 km. northeast of the town of Majagua (see text-fig. 1).

TEXTURE OF THIN SECTIONS AND ENVIRONMENT

Thin sections from both cores show organic fragments, predominantly of algal origin but also angular fragments of mollusks and remains of echinoderms and encrusting and other benthonic foraminifera, embedded in a dark gray microcrystalline matrix. Sulcoperculinas, pseudorbitoids and encrusting foraminifera are common. Planktonic foraminifera have not been seen in the thin sections. However, in the top portion of a slightly shallower core, from 2703–2721 feet, of essentially the same fragmental texture as the cores from 2789–2838 feet, rare specimens of *Globotruncana fornicate* Plummer, *Globotruncana* sp. ex gr. *arca* (Cushman), "Globigerina" sp. ex gr. *cretacea* d'Orbigny, and *Pseudoguembelina* sp. have been encountered in residues of washed material. Texture and organic composition suggest fore-reef environment for these fragmental limestones.

*Aktinorbitoides**Vaughanina**Sulcorbitoides**Rhabdorbitoides**Pseudorbitoides**Historbitoides**Conorbitoides**Ctenorbitoides*

TEXT-FIGURE 1
MAP SHOWING THE LOCATION OF CRISTALES WELL NO. 1A

AGE

Two different pseudorbitoid faunules are recognized. The upper one, from 2789–2808 feet, is characterized by *Ctenorbitoides cardwelli* and *Conorbitoides cristalensis*, and the lower one, from 2808–2838 feet, by *Aktinorbitoides browni*. Because of the absence of planktonic foraminifera in the cores from 2789–2838 feet, the age of the two pseudorbitoid faunules cannot be determined in terms of the *Globotruncana* zonation. The associated benthonic assemblage is the same for both faunules, and consists of:

Vaughanina sp. cf. *V. barkeri* Bronnimann

Sulcoperculina globosa de Cizancourt

Sulcoperculina sp. cf. *S. vermenti* (Thiadsen)

Acervulina cenomaniana (Seguenza)

Placopsisina sp. ex gr. *cenomana* d'Orbigny – *longa* Tappan

Solenopora piai Keijzer

Archaeolithothamnium sp.

UPPER CRETACEOUS PSEUDORBITOIDIDAE

The age significance of this assemblage is rather vague, both Maestrichtian and Campanian age assignments being possible on the basis of *Vaughanina* Palmer and *Sulcoperculina* Thalmann. The occurrence of a *Vaughanina* close to if not identical with *Vaughanina barkeri* Bronnimann suggests a pre-*Vaughanina cubensis* age, i.e., older than upper Maestrichtian.

If the planktonic faunas with *Globotruncana fornicate* Plummer, *Globotruncana contusa* (Cushman), forms transitional between *Globotruncana fornicate* and *Globotruncana contusa*, *Globotruncana rosetta* (Carsey), *Globotruncana stuarti* (de Lapparent) and *Globotruncana* sp. ex gr. *lapparenti* Brotzen found in the core from 2031–2065 feet, and those with *Globotruncana fornicate* and *Globotruncana* sp. ex gr. *arca* (Cushman) found in the core from 2703–2721 feet (top) are in situ, and if the cores from 2031–2838 feet represent a normal stratigraphic succession, then the age of the two pseudorbitoid faunules is late Campanian or early Maestrichtian. Because the stratigraphic succession is not certain, however, the age significance of these planktonic faunas from the shallower cores is problematical. In the writer's opinion, there is little doubt that they are autochthonous and that the stratigraphic sequence is undisturbed. It will also be noted that the age determination afforded by the planktonic faunas does not conflict with the pre-upper Maestrichtian age indicated by *Vaughanina* sp. cf. *V. barkeri*. The age of the two pseudorbitoid faunules is therefore tentatively regarded as late Campanian or early Maestrichtian.

ACKNOWLEDGMENTS

The writer wishes to thank W. H. Cardwell, chief geologist of the Cuban American Oil Company, Dallas, for having made the well samples available and for permission to publish this note. He is also indebted to Ing. G. A. Seiglie, geologist with the Comisión de Fomento Nacional, Havana, for isolated specimens of the conical pseudorbitoids and for information on the planktonic assemblages collected in the well samples; to P. Norton, of the Cuba California Oil Company, Havana, and to N. K. Brown, Jr., of the Gulf Oil Corporation, New York, who kindly showed the writer comparative pseudorbitoid material and who discussed the manuscript with him; and to G. A. Cooper, of the United States National Museum, who obligingly had the holotypes of the conical pseudorbitoids drawn by a National Museum staff artist.

The holotypes of the new species, together with all other figured specimens, will be deposited in the collections of the United States National Museum, Washington, D. C.

SYSTEMATIC DESCRIPTIONS

Superfamily ORBITOIDICAE Schubert, 1920

Family PSEUDORBITOIDIDAE M. G. Rutten, 1935

Genus *Aktinorbitoides* Bronnimann, new genus

Genotype: Aktinorbitoides browni Bronnimann, n. sp.

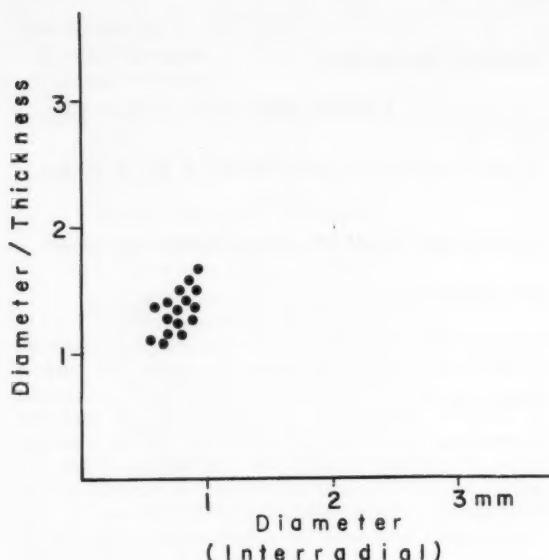
Definition: The lenticular orbitoidal test is aktinate in outline, with seven to ten short, flat radii. The surface seems to be without radial ornamentation. The uniserial trochospiral juvenarium is sulcoperculoid and not differentiated into radii and interradii. The radii proper begin immediately outside the juvenarium. They are formed by two alternating systems of vertical plates, separated by a narrow median gap and crossed by regularly spaced transverse (annular) walls and by lateral chambers. The annular walls are perforated by radial stolons. In cross section, the radii are subcircular near the juvenarium and compressed in a lateral direction at the periphery. The pseudorbitoidal equatorial structure is confined to the radii. The interradii are filled by lateral chambers, which also occur in regular tiers on both sides of the radii and over the juvenarium. Pillars are present.

Comparisons: *Aktinorbitoides* differs from the incipiently stellate genus *Historbitoides* Bronnimann externally in the development of radii and interradii, and internally in the restriction of the pseudorbitoidal equatorial structure to the radii and in the *Vaughanina*-like equatorial layer. *Aktinorbitoides* is similar to *Vaughanina* Palmer in having a uniserial juvenarium and the same equatorial structure; it differs from *Vaughanina* in having an aktinate neanic stage.

Relationships: Possibly *Aktinorbitoides* was derived from *Vaughanina*, which occasionally exhibits a deeply notched periphery. The deepening and increasing in number of peripheral incisions of this type may ultimately have led by palingenesis from *Vaughanina* to *Aktinorbitoides*. The formation of radii in *Aktinorbitoides* is restricted to the neanic stage. The spiral chambers of the juvenarium do not show any sign of radial arrangement, not even in incipient form. This remarkable differentiation between juvenarium and neanic stage supports the suggested palingenetic evolution from *Vaughanina* to *Aktinorbitoides*. *Historbitoides*, which probably developed from a *Pseudorbitoides* ancestor, does not appear to be related to the radiate *Aktinorbitoides*, although the interior stellate morphology might indicate such a relationship.

Occurrence: Cuba and British Honduras.

Age: Upper Cretaceous, probably late Campanian or early Maestrichtian.



TEXT-FIGURE 2

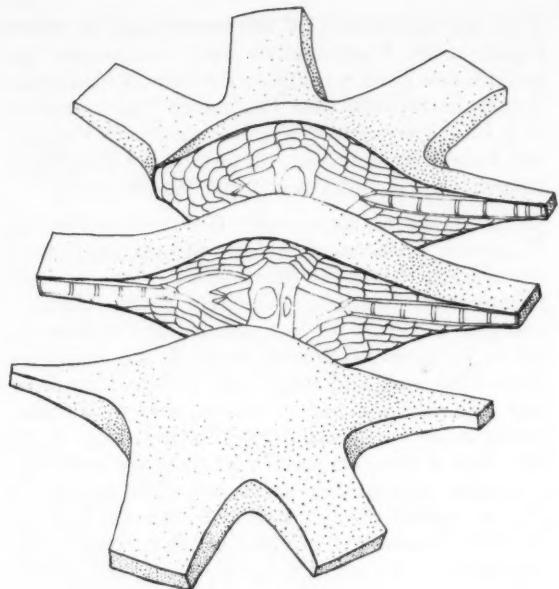
Aktinorbioides browni Bronnimann, n. sp., dimension diagram.

***Aktinorbioides browni* Bronnimann, new species**

Plate 1, figures 1-9; plate 2, figures 1-10;
text-figures 2-6

Holotype: *Aktinorbioides browni* Bronnimann, n. sp., pl. 1, fig. 5. The specimen is from thin section no. 9 of core from 2808-2838 feet in Cuban American Cristales well no. 1 A (for location see text-fig. 1). The maximum diameter of the holotype is 0.64 mm. measured interradially, and 0.9 mm. across opposite radii. The species is named for N. K. Brown, Jr., who first recognized the new pseudorbitoid.

Exterior: Specimens of *Aktinorbioides browni* could not be extracted from the hard limestone. Random cuts indicate a small, strongly umbonate lenticular pseudorbitoid with aktinate periphery. Radii and interradial apparently are not differentiated in the form of ridges and grooves on the surface of the tests. The short radii are irregularly distributed. Adjoining radii may run parallel and almost touch each other, or they may be divergent and far apart. A typical specimen, represented by the holotype (pl. 1, fig. 5), has seven radii. About one-half of the total length of a radius projects outside the test proper. The radii are covered by lateral layers except for their extreme tips, where the vertical radial plates of the equatorial structure are exposed. The peripheral portions of the radii are broad and compressed in a lateral direction, not pointed as in *Asterorbis* or *Asterocyclina*, and their maximum width at the periphery varies considerably in the same specimen. Those of the holotype have a maximum width of 102 μ , 128 μ , and 153 μ , and an average length of about 260 μ , measured from the pointed initial end at the juvenarium to the periphery.



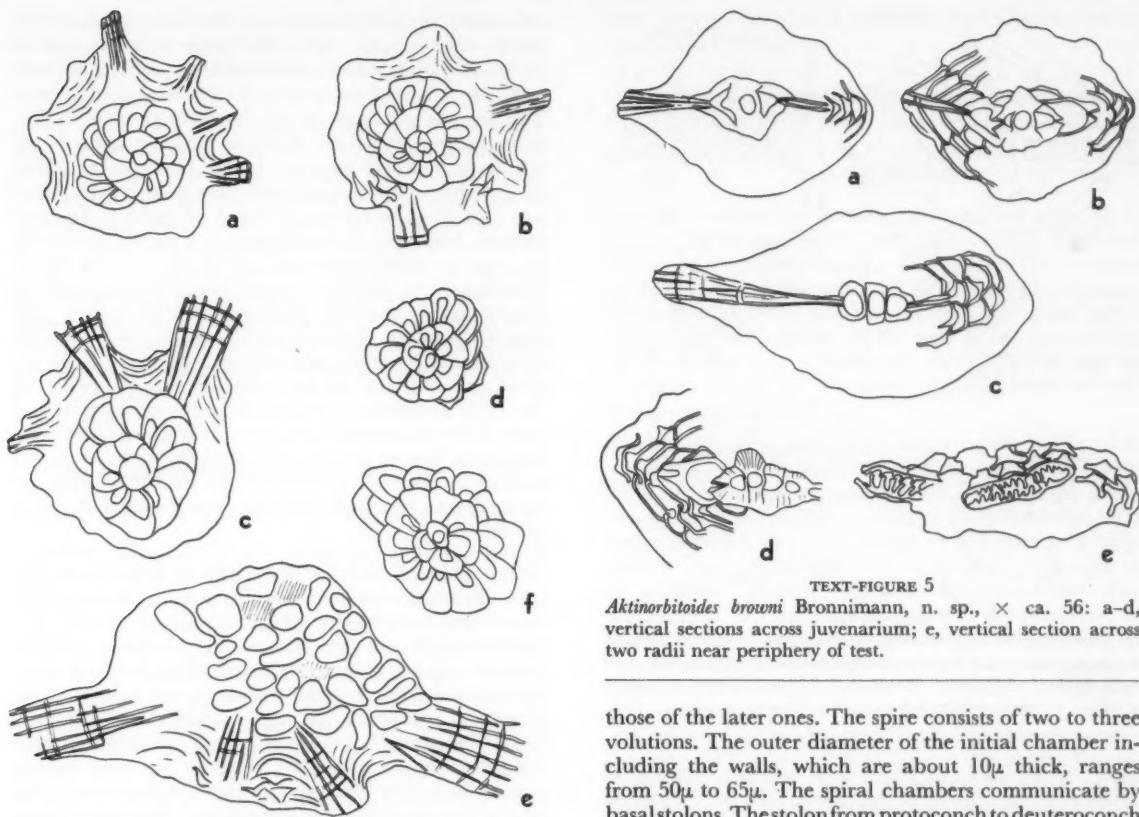
TEXT-FIGURE 3

Aktinorbioides browni Bronnimann, n. sp., schematic model of the test with two typical vertical sections; not to scale.

In other specimens, the radii are 170 μ to 600 μ in length. Oblique sections tangential to the umbos expose thick-walled lateral chambers, and vertical sections occasionally display strong central pillars. The scatter-diagram (text-fig. 2) shows little variation in the dimensions of the tests, which are not grouped into smaller A-forms and larger B-forms, reflecting a primitive uniserial juvenarium. The diameter of tests ranges from 0.5 mm. to about 1.00 mm., measured interradially, and the thickness from 0.5 mm. to 0.7 mm. *Aktinorbioides browni* is one of the smallest lenticular pseudorbitoids found to date. The dimensions of the tests come closest to those of topotypes of *Pseudorbitoides israelskyi* Vaughan and Cole. The schematic model of the test (text-fig. 3) is useful for the orientation of random cuts observed in thin sections. Two characteristic vertical cuts are shown in the model, one across opposite radii and one across interradius and radius. Surface features have not been indicated on the model.

Interior: Random cuts are adequate for the interpretation of the internal organization with the exception of that of the juvenarium, which preferably should be based on centered sections. Perfectly oriented sections have not been found, however, and the following description of the juvenarium is the result of the analysis of more or less centered, somewhat oblique equatorial and vertical cuts. The structure of the characteristic aktinate margin of the test is illustrated by the oblique equatorial cuts of figures 2 and 5-9 of plate 1 and the oblique vertical cuts of figures 1-4 of plate 2. The relationship between juvenarium and aktinate

UPPER CRETACEOUS PSEUDORBITOIDIDAE

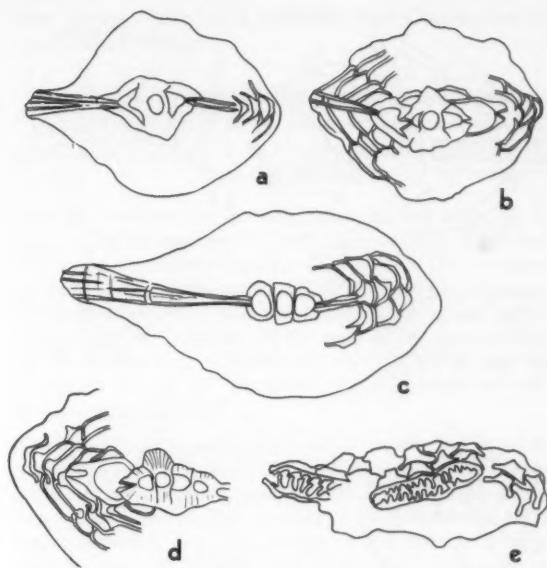


TEXT-FIGURE 4

Aktinorbitoides browni Bronnimann, n. sp., \times ca. 60: a-c, f, juvenaria; e, oblique section showing the structure of the radii.

structure, which is confined to the neanic stage, is shown by the drawings of text-figures 4a-c and 5a-d. Centered vertical sections across interradius and radius expose only lateral chambers on the interradial side of the juvenarium (pl. 2, figs. 1, 3). On the radial side of these vertical sections, the equatorial layer can be seen, covered on both sides by layers of lateral chambers. This difference between the radial and interradial sides, which at first glance is puzzling, is explained by the restriction of the radial vertical plates to the radii. The lateral chambers not only form the normal lateral layers on both sides of the equatorial layer, but they also grow across the interradial portions of the juvenarium. Lateral chambers thus form a protecting cover over the juvenarium and equatorial structures, with a general tendency to produce a lenticular form of test.

1) *Juvenarium*: The uniserial juvenarium starts with a subspherical protoconch, followed by fourteen to seventeen spiral chambers, which increase in size gradually as added. The final chamber or chambers, however, may be smaller than the preceding ones. The walls of the early chambers of the juvenarium are thicker than



TEXT-FIGURE 5

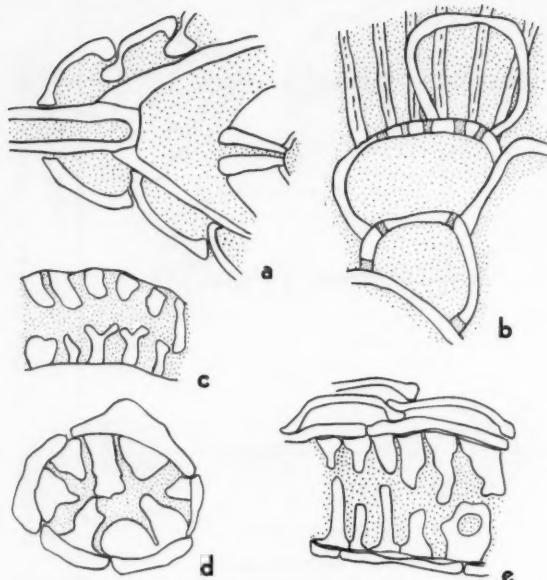
Aktinorbitoides browni Bronnimann, n. sp., \times ca. 56: a-d, vertical sections across juvenarium; e, vertical section across two radii near periphery of test.

those of the later ones. The spire consists of two to three volutions. The outer diameter of the initial chamber including the walls, which are about 10μ thick, ranges from 50μ to 65μ . The spiral chambers communicate by basal stolons. The stolon from protoconch to deutoconch seems to be centrally located. Connections to the lateral chambers are by fine pores. The septa of the spiral chambers consist of two lamellae, which enclose fissural lumina. A true canal system appears to be developed, as in *Sulcoperculina* Thalmann (Brown and Bronnimann, 1957, p. 30, text-fig. 1).

The maximum diameter of the juvenarium is from 300μ to 400μ . The juvenarium is relatively large compared with the interradial diameter of the tests (text-figs. 4 and 5). The three specimens illustrated in text-fig. 4a-c show the following ratios (3) between the diameter of the juvenarium in microns (1) and the interradial diameter of the test in microns (2):

	(1)	(2)	(3)
Text-figure 4a	325	559	0.58
Text-figure 4b	325	533	0.61
Text-figure 4c	390	520	0.75

The form of the juvenarium is perfectly spiral and does not indicate the later aktiniate structure of the test. None of the spiral chambers shows elongation in the direction of the radii. Radii and interradii are structures of the neanic stage. In vertical section, the thick-walled juvenarium is distinctly trochoid, sulcoperculinoid. The spiral chambers are somewhat compressed in a lateral direction and peripherally provided with well developed



TEXT-FIGURE 6

Aktinorbitoides browni Bronnimann, n. sp., \times ca. 270: a, vertical section across late neionic chambers; b, arrangement of radial plates and lateral chambers; c, e, vertical sections across radii; d, vertical section across radius close to the juvenarium.

slci. Comparison of the sulcus of *Aktinorbitoides*, as illustrated in text-figure 6a, with that of *Vaughanina* (Bonnimann, 1954, pl. 10, fig. 10) clearly demonstrates the postulated affinity between these genera also in the formation of the neionic peripheral indentation. Centered juvenaria are illustrated in figures 2 and 9 of plate 2. They show the following dimensions in microns:

	Pl. 2, fig. 2	Pl. 2, fig. 9
Diameter of juvenarium	390	380
Height of juvenarium	156	195
Inner diameter of protoconch	40	32
Height of sulcus	13	12
Radial diameter of largest spiral chamber	78	91
Thickness of dorsal wall of early portion of juvenarium	39	90
Thickness of dorsal wall of later chamber of juvenarium	ca. 6	ca. 6

2) *Neanic stage*: The neanic stage consists of the structurally different radii and interradii. The radii are formed by elements of the equatorial and lateral layers, whereas the interradii contain lateral chambers only. This is very different from the structure of *Historbitoides* Bronnimann or of any of the Tertiary *Aktinocylinas* or *Asterocylinas*. To demonstrate this structural differentiation between radii and interradii, two characteristic vertical cuts have been selected in the

schematic model (text-fig. 3). The first section goes across two opposite radii, the large sulcoperculinoid juvenarium, and the equatorial layer, which in both radii are covered on both sides by lateral chambers. The second cut goes across interradius and radius, showing only lateral chambers in the interradius to the left, but equatorial layer and lateral layers in the radius to the right. Vertical sections across interradii alone are illustrated in figures 2 and 4 of plate 2. In both sections only lateral chambers occur in the interradii. In one of the thin sections (pl. 2, fig. 4), the initial chamber is cut slightly tangentially, but otherwise the juvenarium is perfectly represented. The section goes exactly through the interradii, made up of lateral chambers. The other thin section (pl. 2, fig. 2) is not quite centered, and on the right side cuts at first across the early portion of a radius, as indicated by roof and floor of the equatorial layer; then it remains completely within the lateral chambers of the interradius. Vertical sections across radii or across radius and interradius are illustrated in figures 1 and 9 of plate 2 and by figure 3 of plate 1.

The equatorial layer of the radii is fan-shaped, the pointed initial end touching the juvenarium and the broad end forming the periphery of the radius. The pointed inner ends of the radii are always situated between adjoining spiral chambers. The distal openings of the septal canals in the sulcus appear to be directly related to the formation of the radii. The equatorial layer of the radii is single throughout. It develops from the sulcus at the periphery of the juvenarium and increases in height gradually toward the periphery. The equatorial layer is clearly delimited from the lateral chambers by roof and floor, as in *Vaughanina*. In some instances, transverse (annual) walls have been noted. Cross sections of the radii are rounded near the juvenarium and strongly compressed in a lateral direction at the periphery.

At the periphery of average specimens, the pseudorbitoidal vertical radial plates are 5μ to 7μ thick and about 25μ apart. They are straight, and composed of two lamellae. The boundary between the lamellae is indicated by dark lines. Minute irregularities along the sides appear to connect adjoining plates. This impression of irregular transverse connections may be caused by poor preservation of the delicate plates. In the model (text-fig. 3), they are tentatively represented as in *Vaughanina*, although it is realized that this interpretation may have to be changed. The transverse connections occur over short distances only, across two or three vertical plates. They are about 15μ apart. Occasionally they seem to be somewhat longer, but they can rarely be followed across a complete radius (pl. 1, figs. 5, 7, 9). The subcircular cross sections of radii near the juvenarium exhibit coarse radial plates or rods arranged perpendicular to the axis of the radius (pl. 2, figs. 6, 10). Cross sections near the periphery of the test show two sets of more or less alternating radial plates separated from each other by a narrow median gap. In some instances, the

UPPER CRETACEOUS PSEUDORBITOIDIDAE

plates develop bifurcated inner ends, a feature previously noted in *Vaughanina* (text-fig. 6c). The equatorial structures are sheathed by low primary lateral chambers.

Lateral layers: In average specimens, about seven lateral layers occur on both sides over the juvenarium. They are also formed across the interradii and over the radii. The rather low and long chambers are arranged in regular tiers. They are connected by basal stolons and by fine pores. Strong pillars may occur over the center of the test. Lateral chambers and pillars of average specimens have the following dimensions: Length ca. 64μ ; height ca. 25μ ; thickness of wall ca. 5μ to 10μ ; diameter of pillars at periphery 20μ to 65μ . In oblique sections close to the surface, the lateral chambers appear as thick-walled polygons with an inner diameter of 50μ to 70μ .

Genus *Ctenorbitoides* Bronnimann, new genus

Genotype: *Ctenorbitoides cardwelli* Bronnimann, n. sp.

Definition: The base of the cone-shaped test is flat to slightly umbonate, the flanks are distinctly concave. The apex of the cone, which is on the ventral side of the test, is not pointed but is comb-like, compressed. Lateral chambers and small pillars cover the flanks and base of the cone. The pseudorbitoidal elements consist of two systems of alternating vertical plates, separated by a narrow median gap, and transverse (annular) walls, perforated by radial stolons. The vertical plates radiate from the centrally situated juvenarium to the periphery of the cone, so that they themselves are arranged on the surface of a low cone with the juvenarium at its apex. Vertical plates also project fan-wise to the periphery of the ctenoid apex. The juvenarium tends to be situated in the center of the cone, equidistant from flanks and base. It is uniserial, distinctly trochospiral and sulcoperculinoid. From additional, probably sulcus-bearing neanic chambers on its ventral side, the pseudorbitoidal structures of the ventral fan-like extension develop.

Comparisons: *Ctenorbitoides* differs in the cone-like test and in the development of an apical comb from *Vaughanina* Palmer, to which it is closely related in having the same arrangement of pseudorbitoidal plates. From the cone-shaped *Conorbitoides* Bronnimann it is distinguished by the *Vaughanina*-like internal structure and by the apical comb. The pointed apex of *Conorbitoides* is formed by a protruding pillar-like calcite needle, whereas the apex of *Ctenorbitoides* is formed by pseudorbitoidal plates.

Relationships: *Ctenorbitoides* is structurally closely related to *Vaughanina*. It was probably derived from primitive forms of *Vaughanina* with a strongly trochospiral juvenarium, such as those represented by *Vaughanina barkeri* Bronnimann, by modification of its ventral part, from which the cone-like portion of the test developed.

Occurrence: Cuba.

Age: Upper Cretaceous, probably late Campanian or early Maestrichtian.

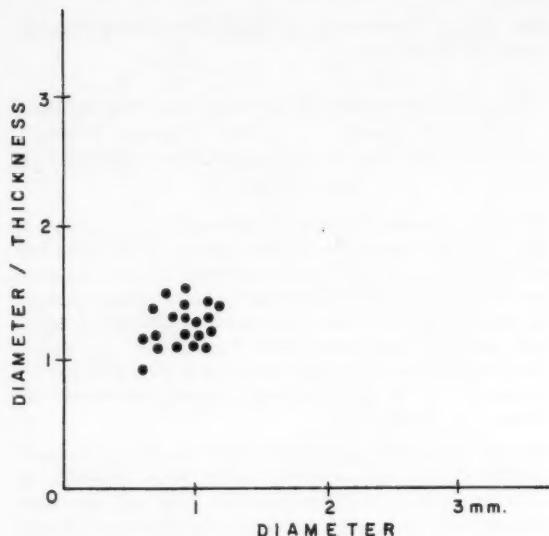
Ctenorbitoides cardwelli Bronnimann, new species

Plate 3, figures 1-6; plate 4, figures 1-7; plate 5, figures 1-4, 6-8, 10-13; plate 7, figures 1-4; text-figures 7-9

Holotype: *Ctenorbitoides cardwelli* Bronnimann, n. sp., pl. 7, figs. 1-3. The specimen is from core at 2789-2808 feet in Cuban American Cristales well no. 1 A (for location see text-fig. 1). The diameter of the holotype is 1.2 mm., the height 0.8 mm., and the width of the apical comb 0.32 mm. The periphery of the base of the cone and of the comb-like apex is 0.095 mm. thick. The new species is named for W. H. Cardwell, Cuban American Oil Company, Dallas.

Exterior: The external features could be studied in well-preserved isolated specimens, which were available in addition to the usual random cuts. The tests are cone-shaped, with flat to slightly umbonate base and distinctly concave flanks. The total height of the cone is usually slightly less than the diameter of the base. The apex of the cone is not pointed, but is flattened, comb-like. The periphery of the base of the cone and the periphery of the compressed apex show two alternating systems of delicate vertical plates separated by a narrow median gap. The plates may bifurcate toward the median gap. The same arrangement is found at the periphery of tests of *Vaughanina cubensis* Palmer. Flanks and base of the cone are covered by thick-walled lateral chambers. Lateral chambers, bordering the periphery of the base of the cone, are elongate radially with walls perpendicular to the periphery. Pillars occur on all parts of the test where lateral chambers are developed. Because of the many pustules on flanks and base, and because of the thick walls of the lateral chambers, the surface appears to be coarsely ornamented. The diameter of the base of the cone ranges from about 0.5 mm. to about 1.2 mm.; the total height of the cone, including the slightly protruding umbo, ranges from about 0.5 mm. to about 0.95 mm. The width of the comb-like apex is 0.3 mm. in a specimen in which diameter and height are both 0.85 mm., and is 0.29 mm. in a specimen with a diameter of 0.97 mm. and a height of 0.83 mm. The dimension diagram (text-fig. 7) shows only one size-group of forms. No dimorphism has been noted.

Interior: Before entering upon the detailed description of juvenarium and neanic stage, some remarks will be made on the position of the juvenarium in *Ctenorbitoides cardwelli* and on the term "equatorial layer." The juvenarium is more or less equidistant from the flanks of the cone and from the center of the surface of the basal umbo (pl. 3, figs. 3-6). This virtually equidistant position of the juvenarium with respect to the centers of the surfaces of the lateral layers is known in all lenticular pseudorbitoids and in all Tertiary orbitoids. The fact that the juvenarium is also equidistant in a cone-shaped pseudorbitoid indicates that the position of the juve-

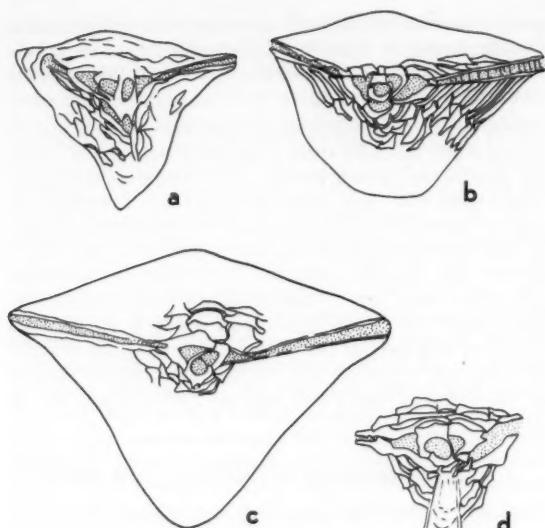


TEXT-FIGURE 7

Ctenorbitoides cardwelli Bronnimann, n. sp., dimension diagram.

narium is a morphologically significant feature of orbitoidal foraminifera in general. The equidistant position of the juvenarium influences the arrangement of the pseudorbitoidal elements. They are situated in an equatorial layer in normal lenticular pseudorbitoids, but are on the surface of a low cone in *Ctenorbitoides cardwelli*, the height of which is determined by the distance from the embryo to the center of the surface of the basal umbo. The term "equatorial layer," which is conveniently and correctly used in all lenticular orbitoidal tests, can therefore no longer be applied in the cone-like *Ctenorbitoides*, and is replaced by the term "conical layer." In the following discussion, all sections perpendicular to the axis of the cone are designated as horizontal sections, and all those parallel to the axis of the cone are designated as vertical sections. Centered horizontal or vertical sections cut across the protoconch.

1) *Juvenarium*: The juvenarium is uniserial. Oblique horizontal sections (pl. 4, figs. 2, 4; pl. 5, fig. 10; text-fig. 9) expose a subspherical protoconch about 65μ in diameter, including the walls, followed by twelve to fifteen spiral chambers, which increase in size gradually as added. The ultimate spiral chambers may be smaller than the preceding ones. The radial diameter of one of the largest spiral chambers is about 130μ . The stolons between the neionic chambers are at the base of the septa. The main stolon from protoconch to deutoconch could not be seen. Communications with the lateral chambers are by means of fine pores. The septa of the spiral chambers are composed of two lamellae, and, as in the juvenaria of other pseudorbitoids, true canals seem to occur. The maximum diameter of the juvenarium is from 250μ to 360μ . Vertical sections show



TEXT-FIGURE 8

Ctenorbitoides cardwelli Bronnimann, n. sp., vertical sections showing structure and equidistant position of juvenarium, $\times ca. 55$.

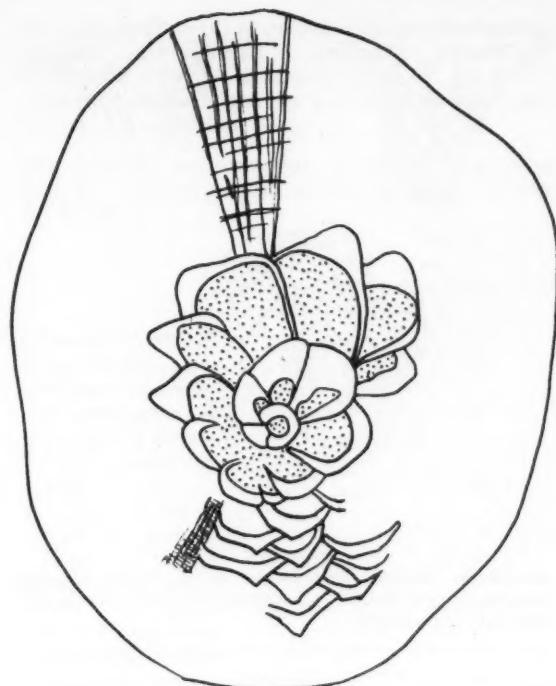
a triangular juvenarium (pl. 3, figs. 3-6; pl. 5, figs. 8, 11, 13; text-fig. 8), with distinct trochospiral arrangement of the spiral chambers, which are provided with peripheral sulci. The sulci of the early spiral chambers are larger than those of the later ones. In some of the sections a sulcus or sulcus-like indentation seems to occur on the ventral side of the trochospire (text-fig. 8; pl. 3, fig. 5; pl. 5, fig. 11). The ventral fan-like system of pseudorbitoidal plates starts from this indentation. The following dimensions, in microns, are taken from the vertical sections illustrated in text-figure 8:

	Text- fig. 8a	Text- fig. 8b	Text- fig. 8c	Text- fig. 8d
Diameter of cone	720	1090	800	—
Height of cone	486	770	605	—
Diameter of juvenarium ..	358	260	258	295
Height of juvenarium	192	154	166	205
Diameter of protoconch, including walls	64	64	—	—
Thickness of dorsal wall of juvenarium	64	40	—	38

The asymmetrical juvenarium leaves no doubt concerning the orientation of the cone. The umbo base of the cone represents the dorsal, and the ctenoid apex the ventral side of the test. The juvenarium occupies a position virtually equidistant from the surfaces of the flanks of the cone and from the center of the surface of the base of the cone.

2) *Neanic stage*: The pseudorbitoid structure, i.e., vertical plates and annular walls, are as in *Vaughanina*. They have been described in detail in a previous note, to

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TEXT-FIGURE 9

Ctenorbitoides cardwelli Bronnimann, n. sp., oblique centered section exposing lateral chambers, juvenarium, and part of conical layer, \times ca. 117.

which the reader is referred (Bonnimann, 1954, pp. 100-102). Distinct roofs and floors delimit the layers with pseudorbitoidal structures from the lateral layers. Because of the equidistant position of the juvenarium, the vertical plates radiating to the periphery of the base of the cone are no longer in an equatorial plane, but are on the surface of a low cone with the juvenarium at its apex, here termed "conical layer." In a typical specimen, almost forty radial plates have been counted per quadrant, as against thirty-two to thirty-six in *Vaughanina cubensis* (Bonnimann, 1954, p. 100). The pseudorbitoidal elements extending ventrally, fan-wise, to the periphery of the ctenoid apex are a characteristic additional feature of the neanic stage. In this fan-like extension their arrangement is the same as in the conical layer, at least in the final stage.

Dimensions of some of the neanic features measured in three of the illustrated thin sections are listed below:

1) Specimen illustrated in figure 1 of plate 3 (an almost centered vertical section with oblique fan-like ventral extension): Diameter of test 0.97 mm.; height 0.65 mm. Thickness of conical layer near periphery, including roof and floor, 40 μ . Thickness of roof and floor of conical layer at periphery 10 μ . Thickness of annular walls less than 10 μ . Average distance between annular walls 12 μ .

2) Specimen illustrated in figure 3 of plate 3 (a centered vertical section): Thickness of conical layer near periphery, including roof and floor, 50 μ .

3) Specimen illustrated in figure 1 of plate 6 (a vertical section close to the periphery of the base of the cone): Thickness of conical layer, including roof and floor, 48 μ . Thickness of vertical plates 5-12 μ . Distance between vertical plates 5-25 μ .

Lateral chambers: The lateral chambers cover flanks and base of the cone-shaped test in regular tiers. They are rather low, thick-walled, and polygonal in oblique section. In a typical centered vertical section, illustrated by figure 6 of plate 3, lateral chambers occur in eight to nine layers over the juvenarium toward the flanks and the base of the test. On the dorsal side they form a distinct umbo; on the flanks they are in slightly concave layers. The diameter of the figured specimen is 1.02 mm., the height 0.85 mm., and the width of the comb-like apex 0.16 mm. The surface of the umbo and of the flanks of the cone are all 0.22 mm. from the triangular juvenarium. The following dimensions are taken from the above-mentioned vertical section, and refer to average lateral chambers: Length 40 μ to 70 μ ; height ca. 12 μ ; thickness of walls 10 μ to 12 μ .

Communications are by means of basal stolons and fine pores. Pillars are from 20 μ to 60 μ in diameter. Horizontal sections between juvenarium and apex show that the lateral chambers are arranged in concentric layers around the axis of the test.

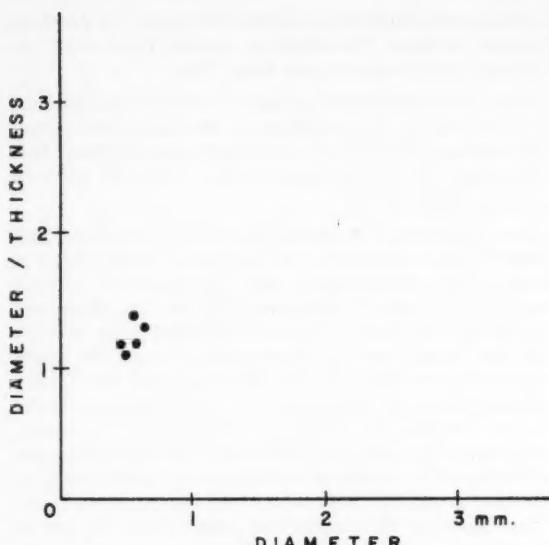
Genus *Conorbitoides* Bronnimann, new genus

Genotype: *Conorbitoides cristalensis* Bronnimann, n. sp.

Definition: The base of the cone-shaped test, or the dorsal side, is flat to very slightly umbonate. The flanks of the cone are straight to concave. The apex of the cone, on the ventral side of the test, is pointed. Lateral chambers occur on the flanks and occasionally on the base of the cone. Juvenarium and neanic stage are uniserial, trochospiral and sulcoperculinoid. The protoconch tends to be equidistant with respect to the surfaces of base and flanks. A thin calcite needle, which gradually increases in thickness to form the protruding pointed apex of the test, occurs in an axial position, on the ventral side of the juvenarium.

Comparisons: *Conorbitoides* differs from the likewise cone-shaped *Ctenorbitoides* Bronnimann in the Sulcoperculinoid-like character of the juvenarium and neanic stage, and in the pointed instead of ctenoid apex. *Conorbitoides* differs from the lenticular *Sulcorbitoides* Bronnimann in the cone-shaped test.

Relationships: *Conorbitoides* is closely related to *Sulcoperculinoides* Thalmann. It was probably derived, later than and independently of *Sulcorbitoides*, from a *Sulcoperculinoides* ancestor by the development of an asymmetrical cone-shaped test. It is remarkable that the two cone-shaped



TEXT-FIGURE 10

Conorbitoides cristalensis Bronnimann, n. sp., dimension diagram.

Upper Cretaceous pseudorbitoids are associated. The sulcoperculinoid *Conorbitoides* may represent a less advanced genus standing between *Sulcoperculina* and *Ctenorbitoides*, which is *Vaughanina*-like in its neanic stage.

Occurrence: Cuba.

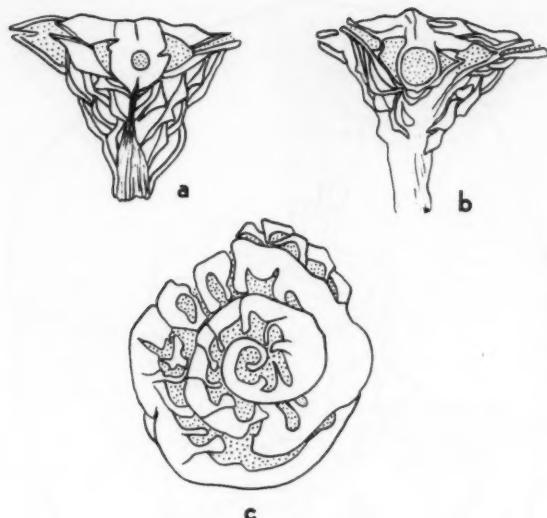
Age: Upper Cretaceous, probably late Campanian or early Maestrichtian.

***Conorbitoides cristalensis* Bronnimann, new species**

Plate 5, figures 5(?), 9(?), 14–16; plate 7, figs. 5–6; text-figs. 10–11

Holotype: *Conorbitoides cristalensis* Bronnimann, n. sp., pl. 7, figs. 5–6. The specimen is from core at 2789–2808 feet in Cuban American Cristales well no. 1 A (for location see text-fig. 1). The diameter of the holotype is 0.53 mm., the height 0.4 mm. The new species is named after the well location Cristales, northeast of Majagua, Camagüey Province, Cuba.

Exterior: The exterior of the new species could be studied in well preserved isolated specimens. The cone-shaped tests are small for pseudorbitoids. The diameter ranges from 0.4 mm. to 0.65 mm., and the height from 0.37 mm. to 0.5 mm. The height of the cone is usually less than the diameter. The largest specimens correspond in dimensions to the smallest specimens of *Ctenorbitoides cardwelli* Bronnimann. The dimension diagram (text-fig. 10), although based on only a few specimens and therefore not conclusive, does not show any grouping



TEXT-FIGURE 11

Conorbitoides cristalensis Bronnimann, n. sp., \times ca. 82: a–b, centered vertical sections; c, centered horizontal section with some lateral chambers.

into smaller A-forms and larger B-forms. The absence of dimorphism suggests a primitive, uniserial juvenarium. The flat base of the cone, which actually represents the dorsal (spiral) side of the test, may show a few lateral chambers. The holotype (pl. 7, figs. 5–6) has no lateral chambers on the flat dorsal side, or at least none that can be seen from the outside. The flanks of the test, excepting the extreme marginal area toward the peripheral sulcus and the protruding axial spine, are covered by large, polygonal, thick-walled lateral chambers. They are in slightly concave layers. No pillars have been seen. The sulcus along the periphery of the base of the cone is very thin, but well developed. Occasionally, short radial plates can be seen in the sulcus.

Interior: The centered horizontal section (text-fig. 11c), which is practically identical with the horizontal section of a small *Sulcoperculina*, shows a spire of two and one-half volutions. It is composed of a subspherical protoconch 60μ to 90μ in diameter, including the walls, and about nineteen spiral chambers, which increase gradually in size. The largest spiral chambers have a radial diameter of 100μ to 120μ , including the outer wall. They are connected by basal stolons. Lateral chambers, indicating the orbitoidal nature of the form, can be seen in this type of section. The centered vertical section, as illustrated by figures 14–16 of plate 5 and by text-figure 11a–b, exhibits low lateral chambers on the flanks and occasionally also on the base of the cone. The *Sulcoperculina*-like portion is strongly asymmetrical and trochospiral. The sulcus of the final whorl is thin and deeply incised. Lateral chambers on the flanks of

UPPER CRETACEOUS PSEUDORBITOIDIDAE

the cone are arranged in irregular concave layers. They may also occur on the base of the cone, producing a very slight umbonal thickening (text-fig. 11b). The axial calcite needle starts as a very thin ventral projection of the umbilical plug.

The following measurements, in microns, are taken from the centered vertical sections illustrated in text-fig. 11a-b:

	Text-fig. 11a (without lateral chambers on dor- sal side of test)	Text-fig. 11b (with lateral chambers on dor- sal side of test)
Diameter of test . . .	460	460
Height of test	364	400
Maximum diameter of apical spine . . .	78	90
Diameter of proto- conch, including walls	—	90
Thickness of dorsal wall of juvena- rium	ca. 65	50-70
Thickness of radial rods	ca. 10	ca. 10
Length of sulcus of peripheral spiral chamber	90	80

Superfamily ROTALIICAE

Family PLANORBULINIDAE Cushman

Genus ACERVULINA Schultze, 1854

Acervulina cenomaniana (Seguenza)

Plate 6, figures 3-5

Planorbulina? cenomaniana SEGUENZA, 1882, R. Accad. Lincei Roma, Cl. Sci. Fis. Mat. Nat., Mem., ser. 3, vol. 12, p. 200, pl. 21, fig. 4.

Archaeocyclus cenomaniana (Seguenza). — SILVESTRI, 1909, Palaeontogr. Italica, vol. 14 (1908), p. 134.

Archaeocyclus cenomaniana (Seguenza). — SILVESTRI, 1910, Pont. Accad. Romana Nuovi Lincei, Mem., vol. 28, p. 118.

Archaeocyclus mid-orientalis EAMES AND SMOUT, 1955, Ann. Mag. Nat. Hist., ser. 12, vol. 8, no. 91, p. 510, pl. 11, figs. 7-11.

The following description is based on random cuts found in thin sections from core at 2789-2808 feet in Cuban America Cristales well no. 1 A (for location see text-fig. 1).

Description: The calcareous, chambered, generally disc-shaped test is either free or attached to a substratum on which it may spread or which it may envelop. The diameter of typical large specimens is from about 2 mm. to 3.6 mm.; the height is about 0.2 mm. As a rule, the test consists of a single layer of large open-arcuate chambers, similar to those of the equatorial layers of *Orbitoides* d'Orbigny. Individual chambers or small

groups of chambers may grow over the early chambers of the first-formed layer. Occasionally, additional irregular chambers may be formed at the periphery of the test. Attached tests are distinctly asymmetrical, the attached side being flat and thin-walled and the opposite free side being formed by the convex, thick and coarsely perforate outer walls of the chambers. Unattached tests, on the other hand, may be symmetrical in vertical section, both sides being similarly developed, with thick, coarsely perforate, convex outer walls. The symmetry or assymmetry of the tests manifests itself in the individual chambers. Stolons are close to the flat side, but are not completely basal in attached forms, and are centered in symmetrical free specimens. The embryo has been seen in vertical sections only, where it appears to be represented by two subglobular chambers, of practically equal dimensions, separated by a straight wall. It is not known whether the neopluteus is spirally arranged. The primary wall of the chambers is a thin, dark, opaque layer, which doubles back at the apertures and forms the dark points so well known in vertical sections of the septa of rotaliids. The secondary wall of the test is a thin hyaline-radiate calcite layer inside and outside of the layer. As in other rotaliids, additional calcite layers are deposited outside of the test, the number, of which corresponds with the number of growth stages. Accordingly, early chambers of the test have a thicker outer wall than later-formed chambers. Communications between chambers are by means of large, circular stolons. Oblique horizontal sections show that the stolons are irregularly distributed. Pillars are not developed.

The measurements, in microns, listed below refer to the specimen illustrated in figure 4 of plate 6. Diameters of chambers are inner diameters, without the outer walls.

Diameter of protoconch	121
Thickness of wall of protoconch	19
Thickness of wall between protoconch and deutoconch	2
Length of chambers	50-200
Height of chambers	50-130
Thickness of outer wall near embryo	20-40
Diameter of coarse pores in outer walls	6-15
Diameter of stolons	15-25

Other specimens show dimensions similar to those listed above for the illustrated form. However, stolons may be found with diameters up to 50 μ , exceptionally up to 70 μ .

Remarks: The forms assigned here with some reservation to *Acervulina cenomaniana* (Seguenza) are practically identical with those described as *Archaeocyclus mid-orientalis* by Eames and Smout (1955) from Campanian porous chalky limestones found in Kuwait Oil Company's Umm Gudair well no. 1, in Kuwait, at 4078, 4126, and 4130 feet. At the type locality, *Archaeocyclus mid-orientalis* is associated with *Pseudodomia complanata* Eames and Smout, *Siderolites skourensis* (Pfender), *Cuneolina cylindrica* Henson, *Cuneolina pavonia* d'Orbigny, and *Globotruncana*

of the *linneiana-lapparenti* group. In the writer's opinion, there is little doubt that *Acerkulina cenomaniana* (Seguenza) and *Archaeocyclus mid-orientalis* Eames and Smout are the same form. The generic assignment, on the other hand, needs to be re-examined. The only other Cretaceous acervulinid, *Acerkulina cretae* Marsson, from the island of Rügen, northern Germany, occurs as small, grumous, enveloping bodies, whereas *Acerkulina cenomaniana* is generally a flat attached or free disc. *Acerkulina cenomaniana* has been noted in many thin sections of late Cretaceous fragmental limestones. In the present material it occurs mainly in the attached form, either on a substratum or intergrowing with *Archaeolithothamnum* sp., *Solenopora piai* Keijzer, and *Placopsisina* sp. ex gr. *cenomana* d'Orbigny - *longa* Tappan. Attached and free forms can be regarded as variants. Gradations can be seen from one to the other, and for this reason they are treated as growth-types and not as separate taxa.

Occurrence: Italy, Kuwait, and Cuba.

Age: Upper Cretaceous.

Superfamily LITUOLICAE

Family PLACOPSILINIDAE Cushman

Genus PLACOPSILINA d'Orbigny, 1850

Placopsisina sp. ex gr. **cenomana** d'Orbigny -
longa Tappan
Plate 6, figures 1, 2, 6

The following description is based on random cuts of this encrusting foraminifer in thin sections of hard, dark gray limestone in core from 2789-2808 feet in Cuban American Cristales well no. 1 A (for location see text-fig. 1).

Description: The large, coarsely arenaceous, chambered test is invariably attached to a substratum. The diameter of the coiled portion of the specimen illustrated in plate 6, figure 1, is 1.3 mm. Other fragments of the test measure up to 4 mm. The large early chambers are coiled, about four or five making up a volution. The early portion of the test shows about two volutions, the later portion appears to be spreading in linear series. The interior of the chambers is simple. The walls are coarsely arenaceous. No floors of the type of the ordinary arenaceous chamber wall are developed on the attached side of the test, except perhaps a thin chitinous film. The apertures are large, elongate oval, and not quite basal. A diameter of 325 μ and a height of 117 μ have been measured in a fragment of a large specimen.

The following measurements, in microns, are taken from the specimens illustrated in plate 6, figure 1 (specimen no. 1) and in plate 6, figure 6 (specimen no. 2). Diameters of chambers are inner diameters, without walls.

	Specimen no. 1 (coiled early portion of test)	Specimen no. 2 (fragment of later portion of test with large chambers)
Diameter of test	1300	3927
Length of chambers	300-600	up to 1100
Height of chambers	100-220	up to 400
Thickness of chamber wall	20-40	50-130
Diameter of apertures	40-60	50-130

Remarks: d'Orbigny's original specimen of *Placopsisina cenomana* is not available. The present form shows affinities to *Placopsisina cenomana* as figured by Reuss (1854, pl. 28, figs. 4-5) from the Turonian of the Gosau Valley, eastern Alps, and to *Placopsisina longa* Tappan (1940, pl. 15, figs. 9-10), from the Lower Cretaceous Grayson formation of Texas. The inner structure of both of these forms is unknown. The Cuban specimens, on the other hand, are available only in thin sections. It appears that *Placopsisina cenomana* and *Placopsisina longa* are representatives of a closely related group of attached Cretaceous foraminifera, to which the Cuban form seems to belong. *Placopsisina* sp. ex gr. *cenomana-longa* is a common component of the layered algal-foraminiferal associations composed of *Archaeolithothamnum* sp. (pl. 6, fig. 7), *Solenopora piai* Keijzer, and *Acerkulina cenomaniana* (Seguenza). It has been encountered in many thin sections of Upper Cretaceous fragmental limestones of fore-reef type.

Occurrence: Cuba, Texas, and Europe.

Age: Upper Cretaceous.

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UPPER CRETACEOUS PSEUDORBITOIDIDAE

EXPLANATION OF PLATES

PLATE 1

All figures of *Aktinorbitoides browni* Bronnimann, n. sp., from core at 2808–2838 feet (middle) in Cristales well no. 1A; all \times ca. 73.

- 1 Slightly oblique equatorial section showing the large juvenarium and peripheral parts of two radii on the lower side. Radial plates are exposed only in the shorter of the two radii. Thin section no. 6.
- 2 Almost centered equatorial section with five or six radii. The *Vaughanina*-like structures are exposed in the two largest radii. Thin section no. 11.
- 3 Vertical cut across interradius, juvenarium and radius. Thin section no. 5.
- 4 Oblique vertical cut across two radii, juvenarium and radius. Thin section no. 9.
- 5 Holotype. Thin section no. 9.
- 6, 8 Oblique tangential cuts across umbo and four radii: 6, thin section no. 7; 8, thin section no. 5.
- 7, 9 Part of an oblique vertical cut exposing the juvenarium and the internal *Vaughanina*-like structure of a radius: 7, thin section no. 7; 9, thin section no. 5.

PLATE 2

All figures of *Aktinorbitoides browni* Bronnimann, n. sp., from core at 2808–2838 feet (middle) in Cristales well no. 1A; all \times ca. 73.

- 1 Cut across interradius, juvenarium and radius. Thin section no. 6.
- 2, 4 Cuts across interradius, juvenarium and interradius: 2, thin section no. 10; 4, thin section no. 6.
- 3, 5 Peripheral vertical cuts exposing cross sections of radii: 3, thin section no. 9; 5, thin section no. 8; 7–8, 10 7–8, thin section no. 3; 10, thin section no. 8.
- 6 Perpendicular section across three radii close to the juvenarium, showing the somewhat irregular arrangement of the radial elements and the rounded cross sections. Thin section no. 4.
- 9 Centered vertical section across radius, juvenarium and radius. Thin section no. 3.

PLATE 3

All figures of *Ctenorbitoides cardwelli* Bronnimann, n. sp., from core at 2789–2808 feet in Cristales well no. 1A. All are vertical sections, \times ca. 73, illustrating the central position of the juvenarium and the low cone formed by the equatorial layer.

- 1, 3–6 Centered, and showing the fan-like ventral development of radial plates: 1, thin section no. 8; 3, thin section no. 6; 4, thin section no. 1; 5, thin section no. 5; 6, thin section no. 9.
- 2 Oblique, outside the juvenarium and the ventral fan. Thin section no. 2.

PLATE 4

All figures of *Ctenorbitoides cardwelli* Bronnimann, n. sp., from core at 2789–2808 feet in Cristales well no. 1A; all \times ca. 73.

- 1, 3, 5, 7 Oblique cuts tangential to the flanks of the test, in figure 1 almost parallel to the flanks, showing the vertical plates of the conical layer and the vertical plates of the comb-shaped apex; indications of transverse plates can be seen in places; lateral chambers are large, thick-walled polygons: 1, thin section no. 27; 3, thin section no. 30; 5, 7, thin section no. 29.
- 2, 4 Oblique sections close to the juvenarium: 2, thin section no. 11; 4, thin section no. 28.
- 6 Vertical section, not quite centered, showing the conical layer, some of the large nepionic chambers, and the structure of the comb-shaped apex. Thin section no. 7.

BRONNIMANN

PLATE 5

1-4, 6-8 *Ctenorbitoides cardwelli* Bronnimann, n. sp., from core at 2789-2808 feet in Cristales well no. 1A.

10-13 1-2, 4, 6-7, vertical and oblique vertical cuts across the peripheral portion of the base of the cone exposing the *Vaughanina*-like type of pseudorbitoidal structure, \times ca. 73: 1, 4, thin section no. 8; 2, thin section no. 3; 6, thin section no. 4; 7, thin section no. 10; 3, vertical section, \times ca. 363, of part of the juvenarium, showing the sulcus; same specimen as in pl. 3, fig. 5; thin section no. 5; 8, 11-13, vertical sections of smaller specimens, in part oblique, but almost centered, \times ca. 73: 8, 11, thin section no. 27; 12, thin section no. 32; 13, thin section no. 10; 10, oblique cut across center of small specimen, \times ca. 73, showing uniserial juvenarium and, on the left side, a portion of the conical layer with *Vaughanina*-like annular walls; thin section no. 15.

5 *Conorbitoides cristalensis* Bronnimann(?), from core at 2789-2808 feet in Cristales well no. 1A. Oblique cut across the test, \times ca. 73; it is not clear whether or not the sulci show *Vaughanina*-like structure. Thin section no. 16.

9 *Conorbitoides cristalensis* Bronnimann(?), from core at 2789-2808 feet in Cristales well no. 1A. Horizontal cut above the juvenarium, \times ca. 73; the lateral chambers are arranged concentrically around the central fan or pillar. Thin section no. 22.

14-16 *Conorbitoides cristalensis* Bronnimann, n. sp., from core at 2789-2808 feet in Cristales well no. 1A. Vertical sections across the small cone-shaped test, \times ca. 73; 14-15, practically centered cuts: 14, thin section no. 1; 15, thin section no. 18; 16, thin section no. 7.

PLATE 6

1-2, 6 *Placopsilina* sp. ex gr. *cenomana* d'Orbigny - *longa* Tappan, from core at 2789-2808 feet in Cristales well no. 1A; all \times ca. 73: 1, initial spire cut almost horizontally; thin section no. 27; 2, 6, vertical cuts across the tests of large specimens; thin section no. 10.

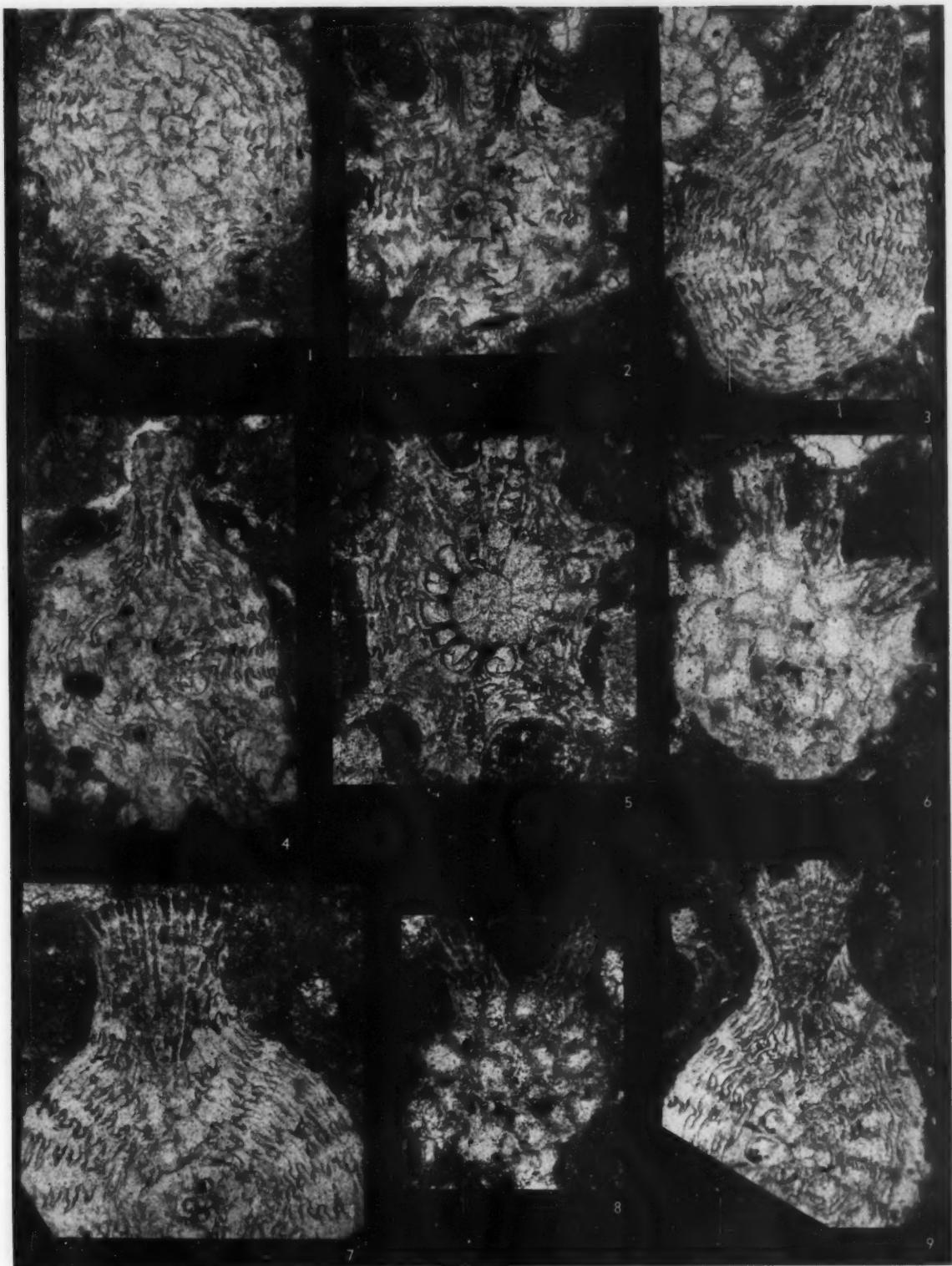
3-5 *Acervulina cenomaniana* (Seguenza), from core at 2789-2808 feet in Cristales well no. 1A; all \times ca. 73. Vertical sections: 4-5, centered; 3-4, thin section no. 21; 5, thin section no. 13.

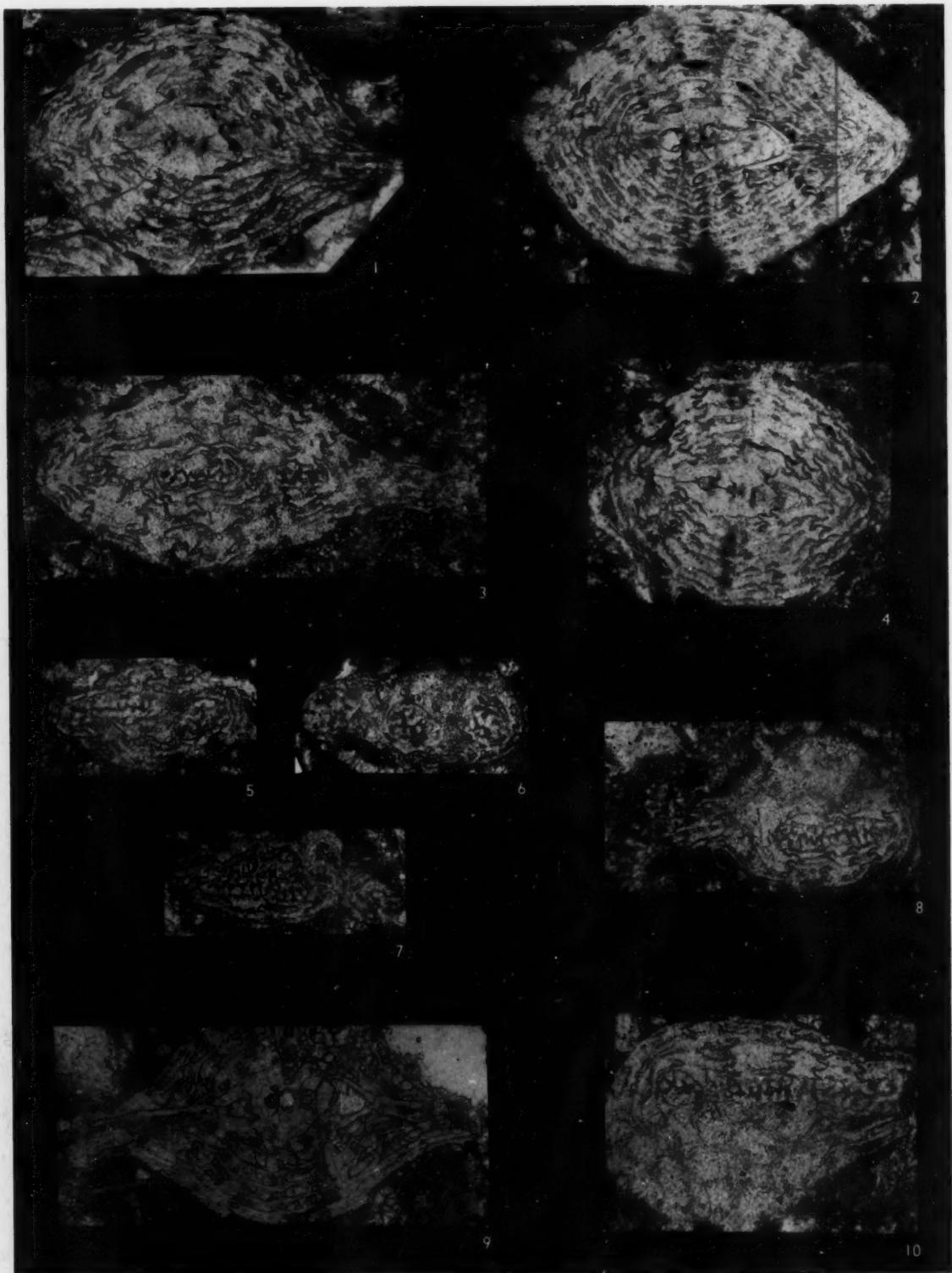
7 *Archaeolithothamnium* sp., from core at 2789-2808 feet in Cristales well no. 1 A; \times ca. 73. Thin section no. 18

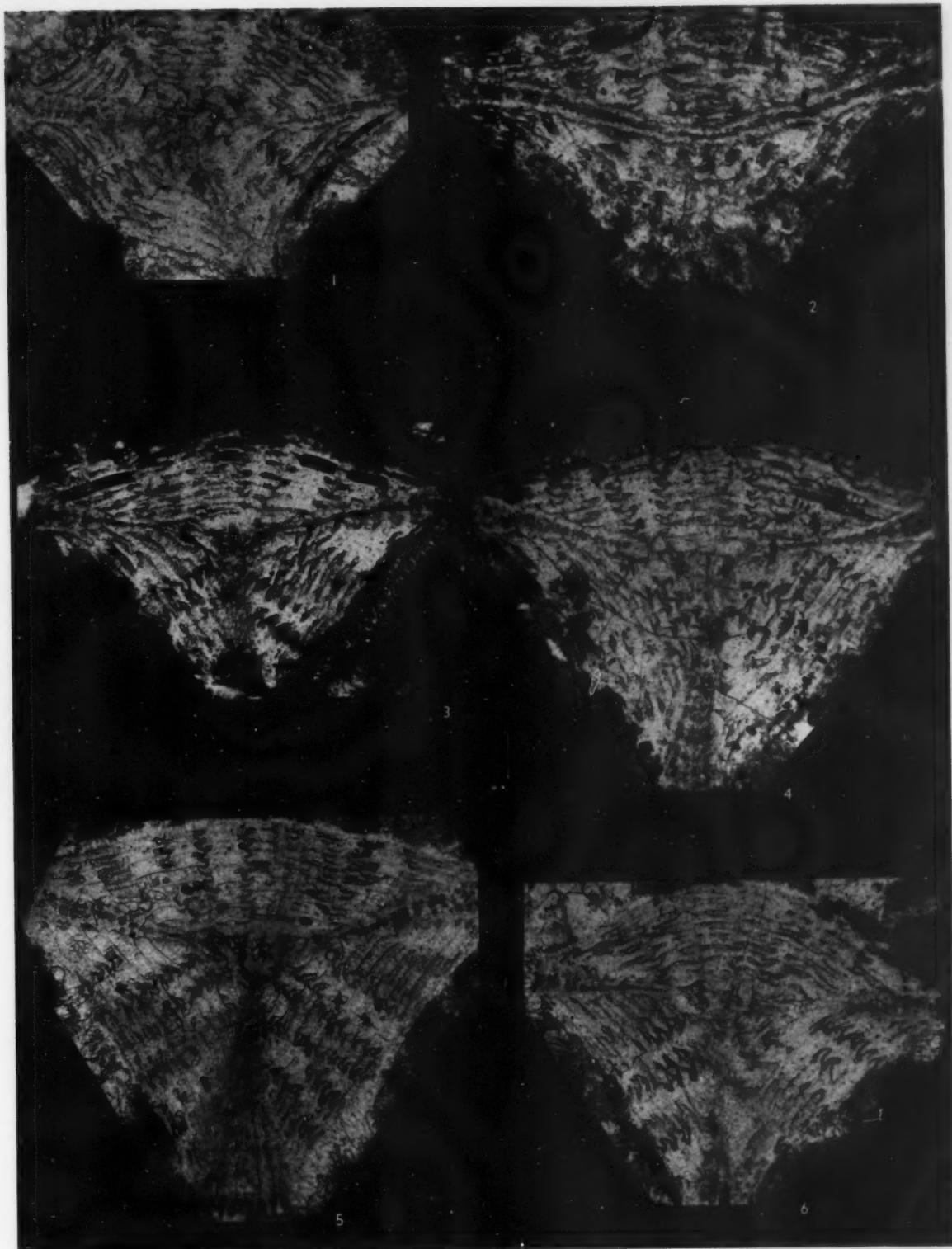
PLATE 7

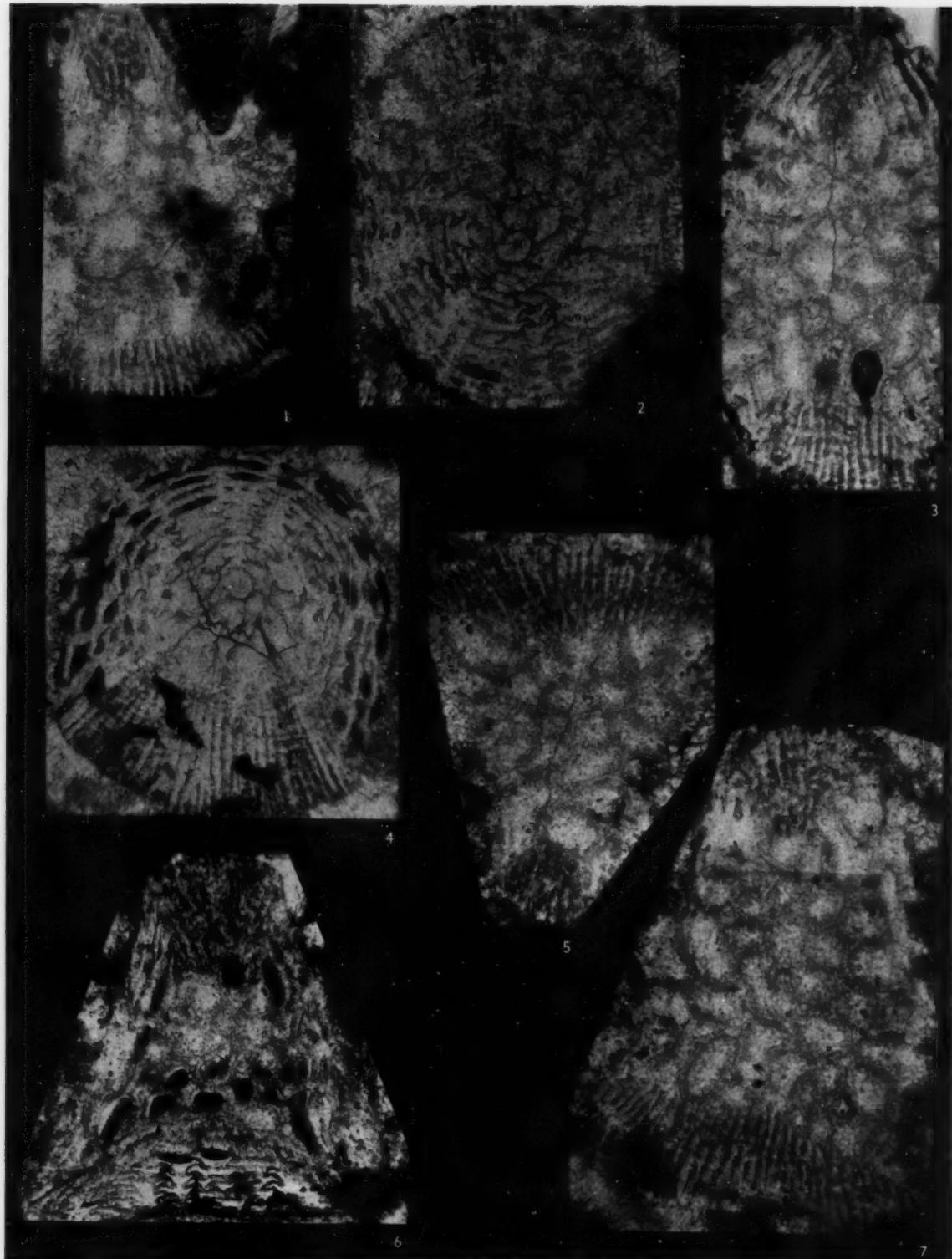
1-4 *Ctenorbitoides cardwelli* Bronnimann, n. sp.
1-3, holotype; 4, paratype. All \times 65.

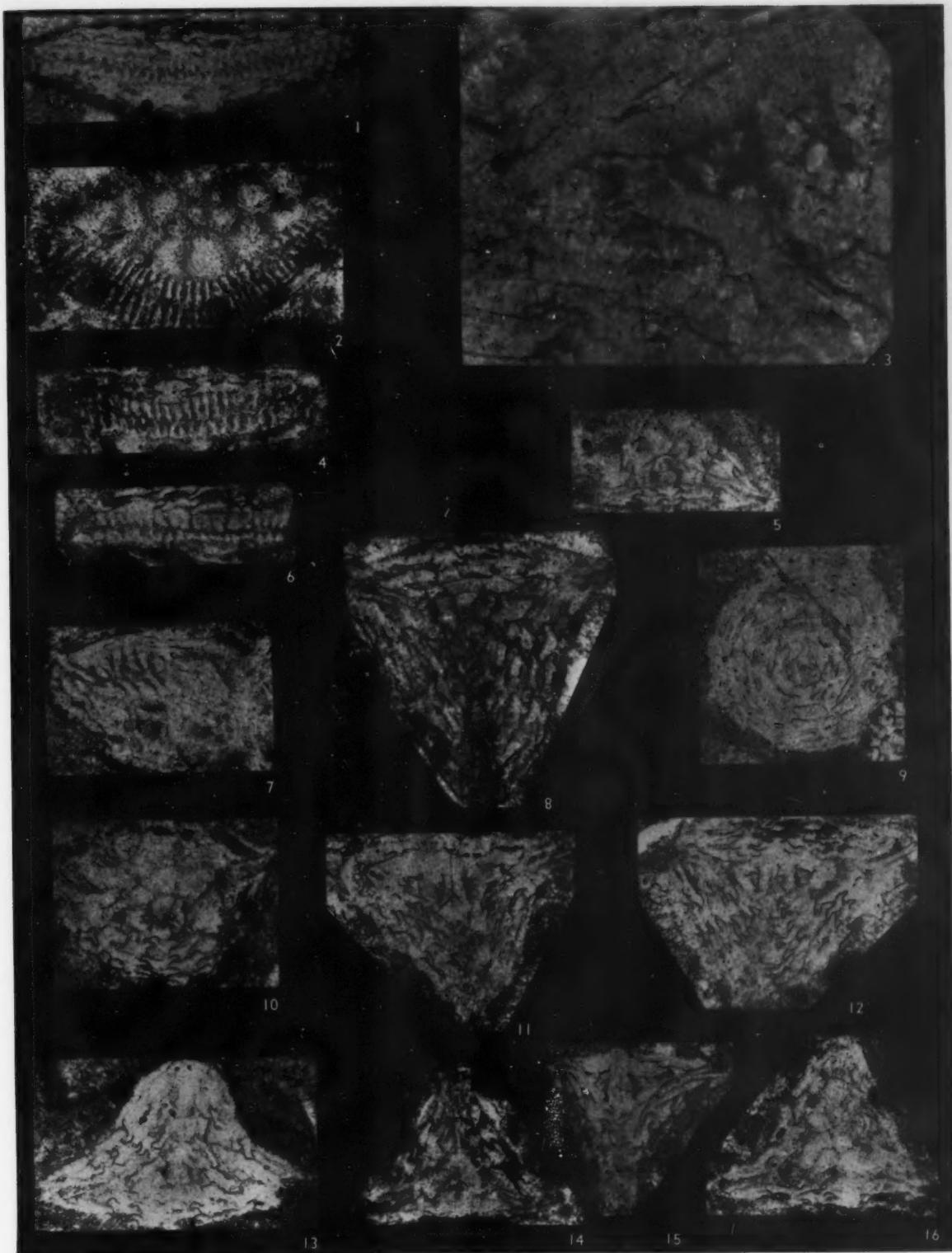
5-6 *Conorbitoides cristalensis* Bronnimann, n. sp.
Holotype; \times 148.

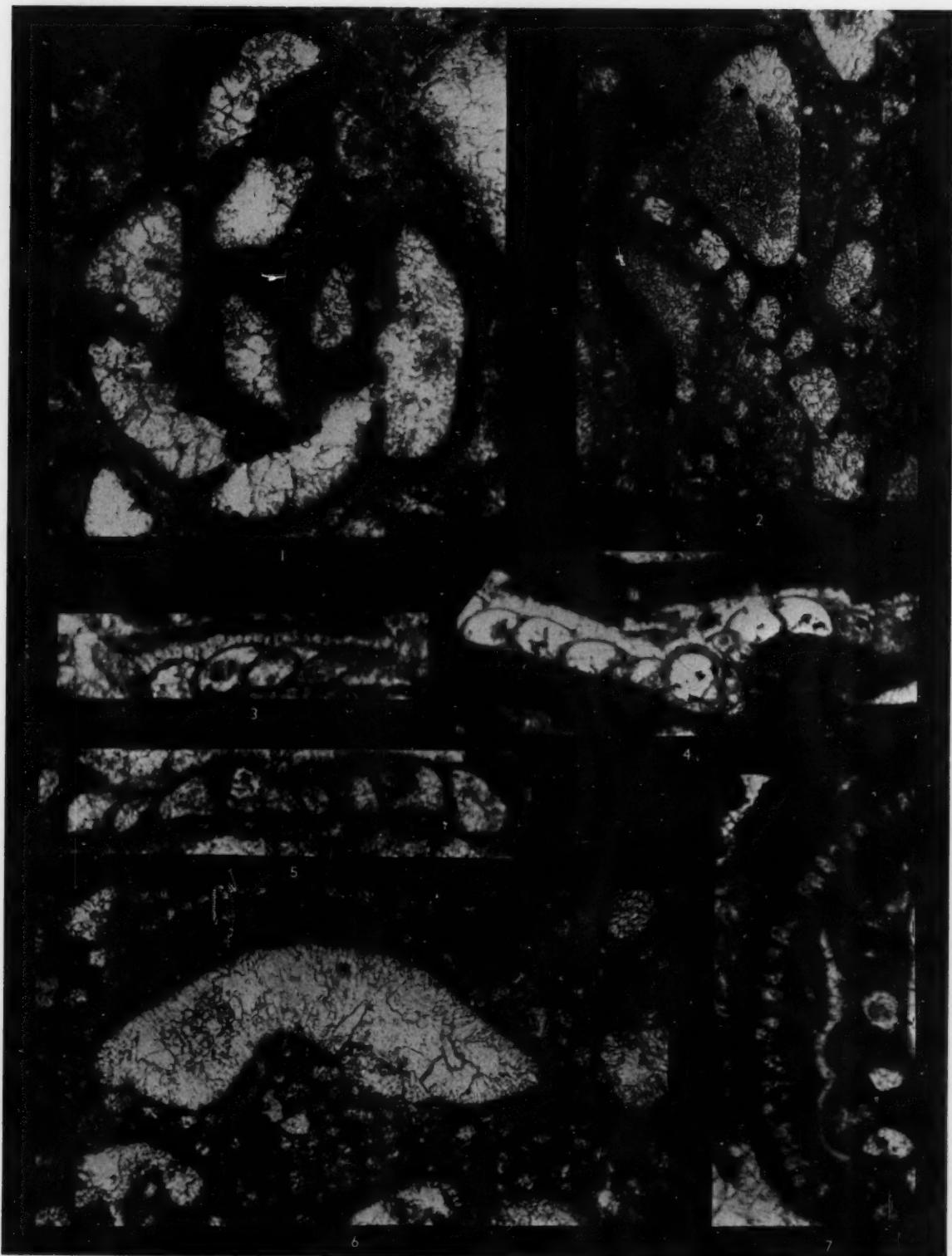
















ABSTRACT: Conodont control of pellet formation in the basal Maquoketa of Iowa is illustrated, and the stages of pellet formation are defined. Dominant types found pelletized are simple cones of the genus *Drepanodus*. Platform, bar, and blade types are also pelletized. Microcrystallinity of the calcium phosphatic sediment composing the pellets, and fine particle-size, are thought to account for the shiny lustre of the pellets and their smooth, even texture, respectively. Evidence on conodont control of pellet formation leads to the further conclusion that growth of the conodont-bearing animal could not have been affected (i.e., retarded) by an influx of calcium phosphate in the Maquoketa sea, since these animals had their demise before that event.

Significance of conodont control of pellet formation in the basal Maquoketa

PAUL TASCH

University of Wichita
Wichita, Kansas

INTRODUCTION

The present report is an offshoot of a larger research study begun in 1954 and still in progress. The larger study concerns the "Fauna and paleoecology of the basal Maquoketa of Iowa." Two grants from the National Science Foundation (G-764, G-2933) have made possible both field and laboratory research on this project.

In the earlier stages of this study, the writer was puzzled at the sparsity of conodonts in the finer fractions of untreated samples. However, flat, elliptical to subround, thin, black to dark gray phosphatic pellets were abundant in all samples. The connection between conodonts and these pellets emerged very gradually.

Upon dissolution of numerous pellets in dilute hydrochloric acid, there remained a dark brown, microcrystalline or fibrous residue. These pellets are being separately studied and will be reported on elsewhere. Another type of residue included both a released conodont and dark brown, phosphatic, speckled, and translucent microcrystalline films. This discovery stimulated the search for pellets that contained microscopically visible, exposed conodonts.

Subsequently, abundant conodonts were found in the finer fractions of untreated samples from some localities. Of these, a sizeable number were wholly or partially surrounded by sediment in the form of a pellet. Recently, another worker (Glenister, 1957) has reported abundant conodonts from the basal

Maquoketa at localities in Clayton County, Iowa. However, the process of separation used (Glenister, 1957, p. 715) necessarily destroyed the evidence of greatest paleoecological significance, namely, the mechanism of conodont control of one type of pellet formation. The present paper treats this aspect.

It may be observed that the sparsity of conodonts originally noted by Ladd (1925), and subsequently by the writer in the course of this work, can now be adequately explained. Similarly, the large, varied conodont fauna found by the writer in several counties in northeastern Iowa and in subsurface samples from Missouri, as well as by Glenister in Clayton County, Iowa, is not in contradiction to this observation. Thus, sparsity of conodonts was merely "apparent" sparsity due to conodont control of pellet formation. Abundance was "actual" abundance when the conodonts were completely or partially separated from the pellets, i.e., by either chemical or mechanical means.

CONODONT CONTROL OF PELLET FORMATION

The simple cone type of lamellar conodont, *Drepanodus*, was most frequently found wholly or partially encased in a pellet. However, platform, bar, and blade types (Fay, 1952, text-fig. 1) were also found in this condition. Generic and specific identifications cannot be given in such cases without destroying the pellet, although equivalent forms found free of pellets are presently being described.

EXPLANATION OF TEXT-FIGURES 1-15

Camera-lucida drawings were made of all figured specimens and reduced. Actual dimensions of specimens were measured with a micrometer eyepiece attached to a binocular microscope, and are indicated on each drawing. Dimensions given are all in millimeters. The letter "p" denotes a pellet or portions of a pellet; "e" denotes a portion of an exposed conodont. Roman numerals I and II, where used, denote successive stages of pellet formation. The specimens illustrated were selected from a larger sample of pelletized conodonts which included specimens from several additional localities. These specimens best show the characteristics of pellet growth. (Illustrations were financed by the University of Wichita Research Fund.)

1-2, 10 *Drepanodus* sp. (probably most simple cone specimens belong to *Drepanodus homocurvatus* Lindström, on the basis of a study of pellet-free conodonts, but certainty of identification is not possible without exposing the aboral surface): 1, early stage of pellet formation, in which the inverted cone (see text-fig. 14) is filled and the pellet continues growth; note that dashed lines indicate the aboral surface and that pelletization has not yet concealed the shape of that surface; locality 7, bed 7.2, Marion Twp., Clayton County, Iowa; 2, the shape of the aboral surface is now concealed, and the pellet has continued to grow on the inner curved surface of the shaft; same locality and bed number; 10, further growth beyond that shown in text-fig. 2; locality 8, bed 8.4, Kaufman Street Quarry, Dubuque, Iowa.

3-4, 6 4, further stage of growth beyond that shown in text-fig. 10; note infilling of inner curved surface of shaft and expanded aboral growth of pellet; locality and bed same as in text-fig. 1; 3, an almost completely pelletized conodont; note that infilling of inner curved surface of shaft advances in an oral direction; locality and bed number same as in text-fig. 1; 6, this specimen shows the type of pellet growth already discussed above, but here, in addition, growth has taken place on the anterior surface instead of continuing in an oral direction; locality 8, bed 8.2, Kaufman Street Quarry, Dubuque, Iowa.

5, 8 5, this specimen shows a sharp contact between two distinct stages of pellet growth, which are indicated by Roman numerals I and II; note that evidence of post-pellet movement is indicated by jagged edge at periphery below aboral surface (see arrow); pre-pellet movement is shown in all illustrated specimens that are broken or truncated; locality 9, bed 9.1, campus of Loras College, Dubuque, Iowa; 8, an almost completely pelletized conodont; lines below the aboral surface indicate successive increments of sediment in this region; in contrast to text-fig. 6, notice that the anterior configuration of this specimen is retained despite the advanced stage of pelletization; same locality and bed as in text-fig. 5.

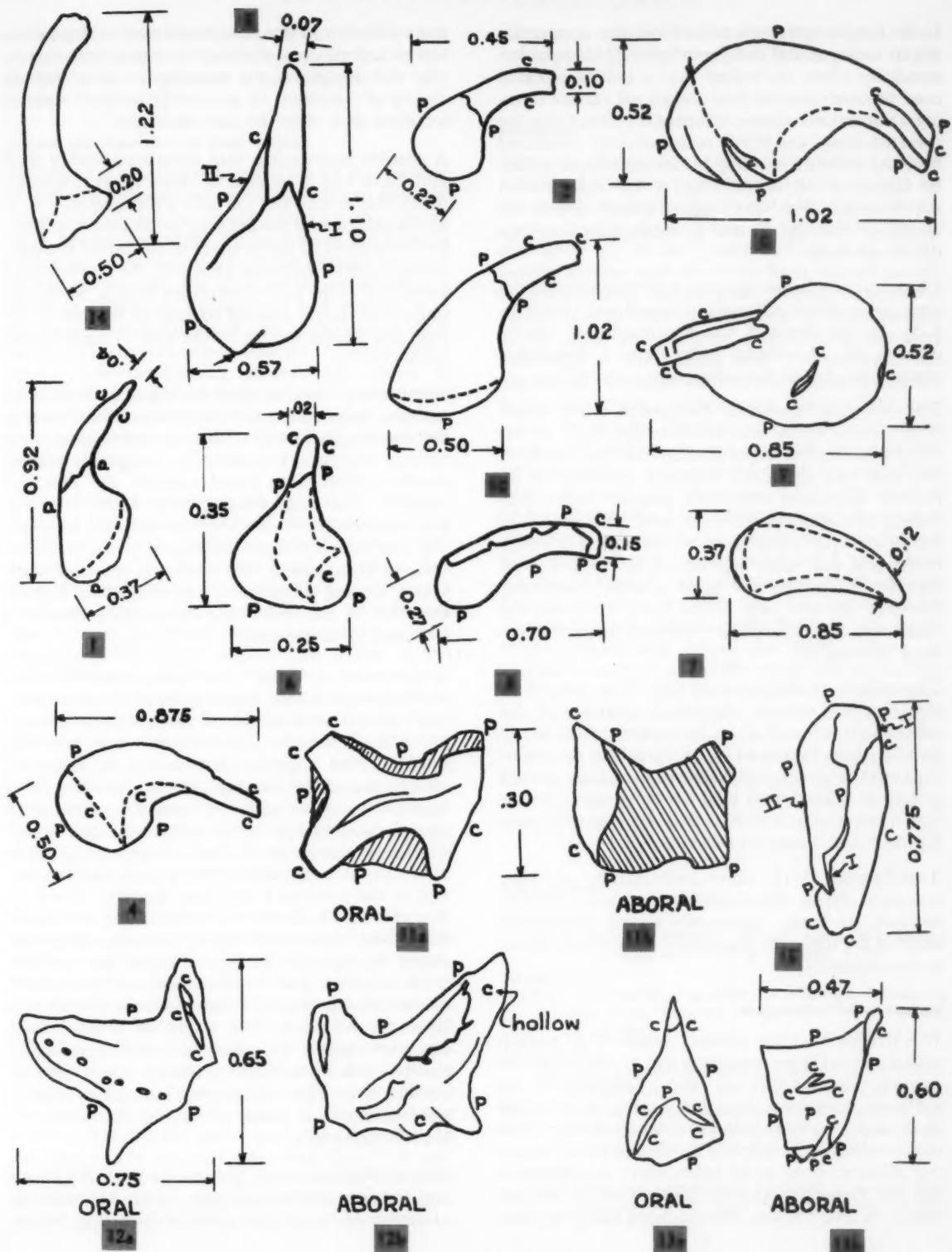
7 A completely pelletized conodont; dashed lines indicate actual configuration of the contained conodont; note the thinness of sediment at the oral tip; this can readily be broken off by slight movement, which may explain why this portion of otherwise completely pelletized specimens is often exposed; at this stage all irregularities of the configuration have been obscured by deposition; locality 16, bed 16.1, Volga River, Sperry Twp., Clayton County, Iowa.

9, 11-13 Platform and other types of conodonts: 9, this specimen shows almost complete pelletization; the interior island labeled "cc" indicates that certain raised areas of the conodont are at best covered by a very thin layer of sediment; same locality and bed as in text-fig. 5; 11a, platform type, showing the mechanism by which the pellet grew around such configurations; note the infilling of all concave sides and the coating of the aboral surface (11b); 12, *Amorphognathus* sp.: a, oral surface, showing median crest exposed through the pellet (properly speaking, a pellet is an ovate body, whereas this specimen has a non-ovate form; however, many specimens of this genus have been found in which the concave sides are also filled in and most of the irregularity removed); b, aboral plate; the exposed portion of the conodont was completely hollowed out; same locality and bed number as in text-fig. 6; 13, *Dichognathus*(?) sp. (control of the nearly triangular shape of the figured specimen suggests this genus): a, oral surface; b, aboral surface; locality 8, bed 8.3, Kaufman Street Quarry, Dubuque, Iowa.

15 Fragment of broken shaft; Roman numeral I indicates basal calcium phosphate coating with rough surface directly in contact with conodont; Roman numeral II indicates the amorphous overlying material of the growing pellet; note the rounding of the irregular fragment surface; locality 6, bed 6.7, Sperry Twp., Clayton County, Iowa.

14 Dashed line indicates configuration of inverted cone at aboral end; the elevation of the apex of this cone above the aboral surface is 0.2 mm.; this cone apparently served as the initial microsedimentary trap which in most cases began the process of pellet formation in unbroken simple cone types of this genus; locality same as in text-fig. 15, bed 6.8.

CONODONT CONTROL OF PELLET FORMATION



In the simple cone types, pellet formation apparently began at the aboral end (text-fig. 1). This is understandable when we realize that a hollow inverted cone proceeds inward from the aboral surface forming a natural microscale sedimentary trap. Once the inverted cone was filled, sedimentation continued over and around it, tending to form smooth, elliptical, or subround curves (text-figs. 2-4). This smooth curve was found to have a jagged indentation in one specimen (text-fig. 5) due to subsequent breakage on the sea floor.

The curvature below the cone axis is apparently the next place where sediment accumulated (text-figs. 4-5). In text-figure 5 the two stages are clearly marked off. The aboral pellet forms a discernible sharp contact with the subsequent curve filling.

The next stage continues this process either nearly to or directly to the oral end (text-figs. 6-7). In the event of no further deposition around the conodont, the oral end remained exposed (text-figs. 5-6). Several variations were then possible under conditions of continued sedimentation. The growth of the pellet could continue on the anterior side nearly to the oral end, either leaving the oral end exposed (text-fig. 6) or, by the same process, completely covering the oral end. If the latter occurred, the result was a concealed or entirely pelletized conodont (text-fig. 7).

The surfaces of the conodont were often covered by thin layers of calcium phosphatic sediment in this process (text-figs. 3, 8). The entire pellet has a smooth, shiny lustre and is quite brittle. It is possible that most of the partially exposed conodonts in such pellets were freed from total containment by breakage. Sharp contacts such as those illustrated in text-figures 5 and 9 support this view.

Text-figures 11-13 show pelletization of other conodont types. Denticulation, curved bounding surfaces, or fangs, apparently served as primary controls for sediment deposition. This is well shown in text-figure 11.

NATURE OF SEDIMENTATION

It is striking that the primary tendency of pelletization around these conodonts was to straighten out existing irregularities in the configuration by sediment deposition. In other words, irregularities in the topography of individual conodonts served as micro-sedimentary traps. This process is, of course, not different from usual sedimentary deposition in the sea. However, what is distinct here is the end result—a discrete, flat, smooth ovate body less than

one millimeter in size. One wonders why deposition was so strictly controlled by the conodonts, that is, why did deposition not continue so as to include dozens of conodonts in an undifferentiated mass of sediment as is often the case elsewhere?

A possible approach is that conodonts freshly shed may have had a mucoid or other organic coating which would hold fine particles streaming onto it. If so, the thickness of the growing pellet would, in part, be determined by the strength of this initial mucoid-bound layer of sediment. However, the nature of the growth of these pellets described earlier would require that such a mucoid coating be limited to the root and aboral surface in the case of simple cone types.

Another problem that arises is the generally smooth-textured shiny surfaces of the pellets. When broken, the interior is found to be an amorphous mass without structure. Occasionally, completely formed smaller pellets were found beneath the removed material. The shiny coating is extremely thin and not otherwise different from the interior material. The calcium phosphatic sediment is microcrystalline and, as stated earlier, the residue is speckled, dark yellow brown, translucent, and sometimes fibrous. Can this be the result of a downfalling stream of sediment on the bottom?

Any movement of these conodonts occurred before or after pelletization. The fangs are often truncated, and many broken specimens freed from pellets are found in the samples. This breakage most probably resulted from pre-pellet movement. As suggested above, the sharp contacts shown between what apparently are successive sedimentary events on a single conodont appear to indicate that post-pellet movement also occurred. In this movement, portions of already formed pellets were broken, and the oral end of the contained conodont exposed. It was at this end that sediment was thinnest. It is unlikely that these conodonts moved to any significant extent during sediment deposition on their surfaces. If these pellets had rolled around on the bottom, one would expect to find some evidence of successive layers of sediment. The stages of pellet growth observed earlier, in which a completely formed smaller pellet was found enclosed like a seed or nucleus in a larger one, merely indicate a break in sedimentation—a pause in the downstreaming of calcium phosphate.

Microcrystallinity may account for the shiny lustre, and the fine particle size may be an adequate explanation of the smooth, even texture. The further

CONODONT CONTROL OF PELLET FORMATION

consideration that the microscopic size of the pellets may conceal minor surface irregularities that would be visible on a larger scale is also probable.

DATING THE CONODONT-BEARING ANIMAL

In view of the observations made above, it is possible to utilize a sedimentary event in order to date the occurrence of the conodont-bearing animal (within early Maquoketa time). Regardless of the horizon within the basal Maquoketa or the distance between collecting localities, the same repetitive sequence is observed. (Data on stratigraphy and fauna are in process of preparation and will be published separately.) This sequence is as follows: (1) Appearance of the conodont-bearing animal; (2) release of conodonts (classifiable into several genera and species) to the sea floor; (3) streaming of calcium phosphate to the sea floor; and (4) pellet formation in several stages.

This repetitive sequence, which can be followed laterally and vertically along the outcrop belt in northeastern Iowa, indicates several kinds of uniformity: (a) The conodont-bearing animal apparently appeared in the early Maquoketa sea in each area prior to pellet formation; (b) pellet formation (around conodonts) was a very uniform process throughout the region studied (uniformity in this instance requires a very detailed matching of specific events culminating in the downstreaming of calcium phosphate or its presence on the sea floor by some other constant mechanism); and (c) the release of conodonts to the sea-floor by the animal bearing them, and the deposition of these conodonts on bottom sediments, were also very uniform processes. This last observation is sustained by the evidence that conodonts show little or no evidence of movement during pellet formation.

From the evidence cited above, it follows that we can date the early Maquoketa conodont-bearing animal not only from the time prior to pellet-formation, but also from the time prior to the influx of calcium phosphate into this sea. Based on the data then available, it seemed logical for Ladd (1925, p. 211) to suggest that phosphate might be a possible cause of depauperization of the fauna in this zone. Tasch (1953, pp. 419-420) reviewed and discussed the biological evidence on this subject and concluded that it did not support this suggestion. In the light of the evidence presented here, it is now possible to state that the influx of calcium phosphate into the early Maquoketa sea indicated by abundant pellets appears to have had no effect whatsoever on

the growth of the conodont-bearing animal, since it occurred after the demise of this segment of the fauna.

ADDENDUM

After the foregoing paper was written, certain additional points seemed important to include for the sake of completeness. At some localities (for example, locality 6, identified in the explanation of text-figure 15), broken portions of the shaft of *Drepanodus* species were found to form almost perfect elliptical pellets. The irregular, broken, most aboral surface of such fragments served in the same manner as the usual inverted cone of specimens that were unbroken at the aboral end. Furthermore, the absence of curvature allowed deposition to coat the entire shaft finely, without the intermediate steps noted for nearly complete specimens. The initial coating of calcium phosphate in such instances had a rough surface, and when the overlying amorphous pellet material is broken away, is distinctly marked off from it (text-fig. 15). A camera-lucida drawing to illustrate the inverted cone is given in text-fig. 14. The apices of such cones stand 0.1-0.2 mm. above the aboral surface. Note should also be made of an Illinois collecting locality (loc. 18, Hanover, Joe Daviess County, Illinois, right bank of the Apple River immediately below the dam), where, in successive horizons above the upper Galena, in beds 18.1, 18.2, 18.4, pelletized conodonts of *Drepanodus* species and of bar and blade types are both strikingly abundant and considerably larger, i.e., both conodonts and pellets are larger here than they are along the Iowa outcrop belt. Finally, some partially pelletized specimens of *Paltodus* species were found at locality 9 (bed 9.1).

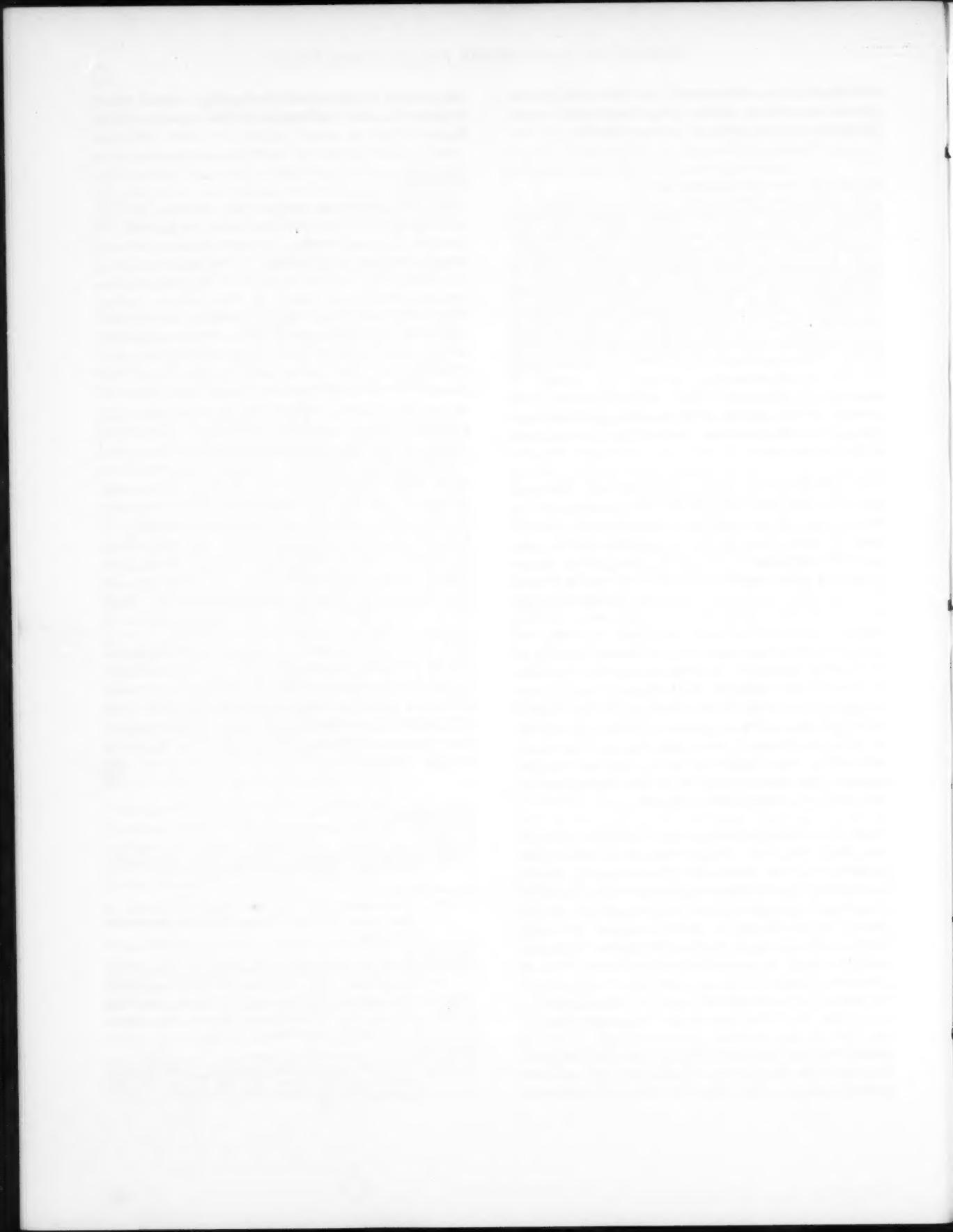
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ABSTRACT: *The nomenclature of the foraminifera is overloaded with synonyms; the reasons for this situation are enumerated. The synonymy of Nonion affine (Reuss) is given as an illustration of this nomenclatorial confusion. This synonymy is the result of a study of types in the United States National Museum, Washington, D.C. Infraspecific categories, their concepts and usage, are discussed. The main purpose of this article is to call attention to the necessity for a greater respect for the basic laws of biology and for the International Rules of Zoological Nomenclature.*

Problems in taxonomy and nomenclature exemplified by *Nonion affine* (Reuss)

ESTEBAN BOLTOVSKOY

*Laboratorio de Foraminíferos
Departamento de Oceanografía
Servicio de Hidrografía Naval, Argentina*

SOURCES OF NOMENCLATORIAL CONFUSION

It is well known that, during recent decades, the nomenclature of the foraminifera has increased so enormously that it has become greatly overloaded with invalid names. This great increase of synonyms is a result of incorrect taxonomic determinations of specimens encountered by many students. These incorrect determinations are mainly due to the following four reasons:

- 1) Absence of literature: This is the most frequent cause of incorrect classification, especially in new laboratories situated far from good libraries. A very worthwhile step toward the elimination of this cause has been taken by B. F. Ellis and A. R. Messina in the publication of the CATALOGUE OF FORAMINIFERA. Unfortunately, due to its relatively great cost and the small number of copies issued, this catalogue is still unavailable in many places where foraminifera are studied.
- 2) Incomplete descriptions and poor figures, both leading to later misunderstanding of species. This handicap can best be overcome by examination of the original material of previous authors. The original material is certainly preferable to the descriptions and figures of even the most careful authors, but this material is usually even more difficult to obtain than the literature.
- 3) Disregard of the basic rules necessary for the erection of a new species or other taxonomic unit, namely, a sufficient number of individuals in a good state of preservation, and the possibility of comparing them with specimens of related species.

4) Ignoring the laws of theoretical biology. This is due to lack of comprehension of the species and subspecies concepts. Many Twentieth Century authors interpret these concepts very narrowly. Even minute details, such as ornamentation, size, and number of chambers, are sometimes considered sufficient reasons for the erection of new species.

Individual students can do little to overcome the first two of these difficulties. The last two, however, are completely within the control of all of us, and they must be considered with great attention. With regard to the lack of consideration of the basic rules that should be applied before the erection of a new species, sufficient has already been written, and repetition is unnecessary. An interesting paper dedicated to this problem was recently published by Hiltermann (1955). Little has been written, however, about the necessity of applying the laws of theoretical biology in our investigations of the foraminifera. I therefore take the liberty of reminding my colleagues of an earlier article on this subject published three years ago (Boltovskoy, 1954). The main purpose of that article was to bring to the attention of all students the necessity for stricter observance of the principal laws of biology relating to the species concept, the fundamental unit in biological science. I hoped at that time to stimulate an exchange of opinions which would be useful to all of us, "not only in the theoretical, but also in the practical field."

In spite of what I believed to be its timely appearance, that article aroused only slight interest. The

responses were few, and consisted only of some letters and a single article by Drooger (1954). The bulk of names continued and still continues to grow chaotically, causing more and more confusion in the work of students of the foraminifera. Even in those cases where invalid new names are not established, but only a list of identified species is given, taxonomic difficulties can be increased by the listing of synonyms. I am far from believing that all species have already been discovered and described, but I do assert that many "species" have been established on the basis of data and diagnostic features that do not meet the requirements of the zoological "species" concept.

These basic laws of the species and subspecies concept are as follows: All specimens referred to the same species should have transitional forms, but such forms should not exist between two different species. At the same time, transitional forms between two subspecies of a species can exist. Specimens of different species cannot, in general, interbreed; if interbreeding takes place, the offspring are not fertile. Specimens of two subspecies interbreed freely and have fertile descendants. As a result of this, two subspecies of a given species *cannot coexist* in the same region, as they will lose their characteristic features (by interbreeding). Two species of the same genus can certainly coexist, but it has long been observed by zoologists and botanists that related species avoid living together in the same region, or if they do, they select habitats with different ecologic conditions.

These basic laws, with some minor additions about which I wrote in the article mentioned above, cannot, I believe, be disputed by my colleagues. But there is one additional thesis, which is not accepted by many investigators, and this thesis often leads to confusion. This is the case of the category "varietas" (variety). Somewhat later in this article I shall discuss whether this category is or is not necessary in our work, but in any case we should obey the existing International Rules of Zoological Nomenclature. According to these Rules, the category "variety" has no validity, and therefore a name first appearing as "n. var." has no valid status and "defense." If an author describes a new variety and wishes to make it valid, he must consider this form as a new subspecies, and must transfer it to that category. But how can this be true if there are two, or even more, described "varieties" of a species existing in one area, when, according to the subspecies concept, this situation is impossible from a biological point of view?

The present article is an outgrowth of the ideas first expressed in the article written three years ago. At that time, the arguments against the increase in the number of invalid names were based solely upon theoretical considerations. I now wish to show practically, by one illustrative example, the large number of invalid names used for a single species, and the resulting and repeated errors of those working with foraminifera. The decision to write the present article arose from interesting discussions with Ruth Todd and other micropaleontologists, and from the study of collections in the United States during a visit to that country made possible by the generosity of the John Simon Guggenheim Memorial Foundation.

THE CASE OF *NONION AFFINE* (REUSS) AND ITS RELATIVES

While working with Recent South American material which I brought to the United States for comparison with collections in North American museums, I noted that specimens of one species of *Nonion* were identical with the type specimens of several species in the collections of the United States National Museum in Washington, D. C. Subsequent searches in this collection, as well as in the Cushman Collection, brought to light other identical forms with still different names. There was no alternative but to search through all of the rich material in these collections and the appropriate literature. In spite of the abundance of this material, the task of elucidating the synonymy of the many "different" species of this group was relatively easy, because of the primitive structure of the genus *Nonion*. I include here only the citations for which I had at my disposal the actual type specimens. It should be noted that, in the Cushman Collection, the term "plesiotype" is used for specimens that have been figured in some published work, but that, in the United States National Museum Collection, both "plesiotype" and "hypotype" have been used for such specimens.

I prefer to write this synonymy in the "classical" form which was used by Williamson, Brady, and Heron-Allen and Earland, and suggested by Rudolf Richter in his excellent book "Einführung in die Zoologische Nomenklatur" (1948). According to Richter, it is desirable to put the year of issue of the work first, then the name (citation with all supplementary words) of the form as it was written by the author in question, and finally the author, name of the journal, and other bibliographic data. After each citation I have added in brackets the geologic age, locality, character of the type material, and, if any existed, the catalogue number in the respective

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collection. The resultant synonymy of *Nonion affine* (Reuss) is as follows:

Nonion affine (Reuss, 1851)

1851 *Nonionina affinis* m. — REUSS, Deutsch. Geol. Ges., Zeitschr., vol. 3, p. 72, pl. 5, fig. 32 [Oligocene, Germany; topotypes, Cushman Coll., no. 12196].

1880 *Nonionina formosa* n. sp. — SEGUENZA, R. Accad. Lincei, Atti, ser. 3, vol. 6, p. 63, pl. 7, fig. 6 [Tertiary, Italy; topotypes, Cushman Coll., no. 39919].

?1899 *Nonionina umbilicatula*, Montagu, sp., var. *depressula*, n. — SILVESTRI, Pont. Accad. Nuovi Lincei, Mem., vol. 15, p. 333, pl. 11, fig. 15 [Pliocene, Italy; specimens (topotypes?), Cushman Coll., no. 6782].

1926 *Nonionina umbilicatula* (Montagu). — CUSHMAN AND APPLIN, Amer. Assoc. Petr. Geol., Bull., vol. 10, no. 2, p. 182, pl. 10, figs. 14–15 [Eocene, U.S.A.; plesiotypes, Cushman Coll., no. 5427].

1929 *Nonion affinis* (Reuss). — CUSHMAN, Cushman Lab. Foram. Res., Contr., vol. 5, pt. 4, p. 89, pl. 13, fig. 24 [Miocene, Ecuador; plesiotypes, Cushman Coll., no. 14350].

1930 *Nonion planatum* Cushman and Thomas, n. sp. — CUSHMAN AND THOMAS, Jour. Pal., vol. 4, p. 37, pl. 3, fig. 5 [Eocene, U.S.A.; holotype, U. S. Nat. Mus. Coll., no. 371168].

1934 *Nonion pacifica* (Cushman). — CUSHMAN, Bishop Mus., Bull., no. 119, p. 120, pl. 4, fig. 7 [Pliocene, Fiji; plesiotype, Cushman Coll., no. 23921].

1936 *Nonion nicobarensis* Cushman, n. sp. — CUSHMAN, Cushman Lab. Foram. Res., Contr., vol. 12, p. 67, pl. 12, fig. 9 [Pliocene, East Indies; holotype, Cushman Coll., no. 23325].

1936 *Nonion pomphiloides* (Fichtel and Moll). — CUSHMAN, Geol. Soc. Amer., Bull., vol. 47, p. 422, pl. 2, fig. 10 [Tertiary, U.S.A.; plesiotypes, Cushman Coll., no. 22862].

1938 *Nonion affinis* (Reuss). — KLEINPELL, Miocene stratigraphy of California, p. 229, pl. 6, figs. 3, 7 [Miocene, U.S.A.; plesiotype, U. S. Nat. Mus. Coll., no. 497176].

1945 *Nonion pacificum* (Cushman). — CUSHMAN AND TODD, Cushman Lab. Foram. Res., Spec. Publ., no. 15, p. 36, pl. 5, fig. 26 [Miocene, Jamaica; plesiotype, Cushman Coll., no. 44404].

1948 *Nonion planatum* Cushman and Thomas. — CUSHMAN, Maryland, Dept. Geol. Min. and Water Res., Bull., no. 2, p. 232, pl. 18, fig. 1 [Eocene, U.S.A.; plesiotype, Cushman Coll., no. 61604].

1948 *Nonion cf. barleeanum* (Williamson). — PARKER, Harvard Coll., Mus. Comp. Zool., Bull., vol. 100, no. 2, p. 239, pl. 3, fig. 3 [Recent, North Atlantic Ocean, 142 meters; plesiotype, U. S. Nat. Mus. Coll., no. 28118].

1949 *Nonion nicobarensis* Cushman. — BERMUDEZ, Cushman Lab. Foram. Res., Spec. Publ., no. 25, p. 116, pl. 11, fig. 20 [Miocene, Dominican Republic; plesiotype and other specimens, Cushman Coll., nos. 63436, 63397].

1949 *Nonion umbilicatum* (Walker and Jacob). — SAID, Cushman Lab. Foram. Res., Spec. Publ., no. 26, p. 23, pl. 2, fig. 32 [Recent, Red Sea, 30–433 meters; plesiotype, Cushman Coll., no. 55626].

1952 *Nonion vicksburgense* Todd, n. sp. — TODD, U. S. Geol. Survey, Prof. Paper, no. 241, p. 22, pl. 3, fig. 21 [Oligocene, U.S.A.; holotype, Cushman Coll., no. 47652].

1952 *Nonion barleeanum* (Williamson). — CROUCH, Amer. Assoc. Petr. Geol., Bull., vol. 36, no. 5, p. 826, pl. 1, fig. 12 [Recent, North Pacific Ocean, 1025 fathoms; hypotype, U. S. Nat. Mus. Coll., no. 548405].

1953 *Nonion formosum* (Seguenza). — PHLEGER, PARKER AND PEIRSON, Swedish Deep-Sea Exped., Rept., vol. 7, fasc. 1, p. 30, pl. 6, fig. 5 [Recent, North Atlantic Ocean, 4480 meters (core); hypotype, U. S. Nat. Mus. Coll., no. 28113].

1954 *Nonion formosum* (Seguenza). — PARKER, Harvard Coll., Mus. Comp. Zool., Bull., vol. 111, no. 10, p. 506, pl. 6, fig. 3 [Recent, Gulf of Mexico, 117 meters; hypotype, U. S. Nat. Mus. Coll., no. 28114].

The differences between each of the forms described by these authors and what could be observed in a study of the actual specimens is noted below. In making these observations, I have been extremely cautious, placing species in synonymy only when convinced, beyond a possibility of doubt, of their specific identity.

1) *Nonionina affinis* Reuss, 1851: According to the description given by Reuss, this species has a coiled, involute, equally compressed test, composed of ten slightly curved chambers. Walls densely and finely perforate. Aperture short, crescentiform. Longer diameter 0.28–0.30 mm. The original figure supplements this description by demonstrating the rounded peripheral margin and the presence of the typical relatively small but deep umbilical cavity. The perforations are illustrated as closely spaced and rather coarse.

Examination of excellently preserved topotypes has confirmed the existence of these features and resulted in the description of others: a) The aperture has an indistinct enlargement in the central part of the base of the apertural face, and it extends on both sides as a fissure along the basal line; b) the sutures are limbate, but their width varies somewhat; furthermore, in general they are wider near the umbilicus, where they form a circle of varying size at the circumference, inside of which the umbilical cavity is situated. This cavity has a very remarkable character; it often has steep sides, and may be irregular in shape and of variable depth; sometimes it is almost totally covered by shell material. Two more small additions to the description may be mentioned: The number of chambers in the last whorl is ten to eleven, and the apertural face in some specimens has a very slight tendency toward a triangular form. The ratio between the longer diameter and the thickness of the test is 30:15 = 2,

or somewhat more (2-2.3). This ratio (about 2) remains rather constant at all geologic horizons. According to the original figure it is greater than in the topotypes, but this is obviously in error, as among a large number of topotypes on many slides none was so compressed.

2) *Nonionina formosa* Seguenza, 1880: In erecting this form, Seguenza compared it with another species described by him at a somewhat earlier date (*Nonionina subcarinata* Seguenza, 1862), but from his description and figure the great similarity existing between *Nonion affine* and *Nonion formosum* is apparent. Comparison of topotypes confirmed this. The topotypes of Seguenza's species are slightly larger and are in a poor state of preservation, as they are filled with matrix. Nevertheless, they clearly show the same type of aperture (differing in the same way as Reuss' topotypes differ from Reuss' original figure), the same perforation, and the same umbilical cavity. The triangular character of the apertural face as shown by Seguenza is not present in all the specimens, and in reality is not as pronounced as represented by him. This feature does not exist as a difference between the species of Reuss described above and that of Seguenza. Probably the single difference that can be observed (and then only as a result of a determined effort to find *any* difference) is the insignificantly greater relative thickness of *Nonion formosum*, or in other words, the ratio between the greatest diameter and the thickness of the test, which is equal to 2 or slightly less. This difference in the specimens observed is inadequate even for subspecific separation. I have no hesitation, therefore, in considering this species of Seguenza as a synonym of *Nonion affine* (Reuss). The explanation of the error made by both Reuss and Seguenza in illustrating the aperture is probably as follows: It is well known that when a chamber is added to *Nonion*, the aperture of the previous chamber becomes enlarged by solution. Specimens with a missing or broken final chamber are often encountered, and very probably both authors drew such specimens. Their figures therefore represent specimens with an unusually large aperture.

3) *?Nonionina umbilicatula* (Montagu) var. *depressula* Silvestri, 1899: If Silvestri's original material or topotypes were available, I believe that this form would also prove to be *Nonion affine*, as Silvestri's description and figure appear to be identical with those of that species. Unfortunately, such type material does not exist in the United States. However, specimens are present in the Cushman Collection from the Pliocene of Castellarquato near Piacenza, Italy, which is situated some distance

northwest of Silvestri's type locality, Coroncina, Province of Siena. These specimens are identified by Cushman as *Nonionina umbilicatula depressula* Silvestri. They are similar to the description and figure given by Silvestri, and identical with topotypes of *Nonion affine* except that the sutures of the final chambers are somewhat deeper than in the latter form. This single and minute difference certainly has no taxonomic value, but as these specimens are not true topotypes, an interrogation mark is placed before the citation.

4) *Nonionina umbilicatula* (Montagu) of Cushman and Applin (1926): Cushman and Applin's hypotype of this form is entirely identical with the topotypes of *Nonion affine* in the Cushman Collection.

5) *Nonion affinis* (Reuss) of Cushman (1929): Examination of this specimen permits no doubt as to its identity with *Nonion affine*.

6) *Nonion planatum* Cushman and Thomas, 1930: The authors compared this form with *Nonion umbilicatum* on the basis of fossil material identified by other students, and stated that such identifications are always doubtful because that species was originally described as a Recent form. As their specimens were also fossil (Eocene), they wrote that it "... seems best to give our form a different name." The description and figure show its great similarity to *Nonion affine*. A comparison of the available material showed that they are identical in all features except that the topotypes of *Nonion affine* are somewhat larger (diameter 0.3 mm. as compared with 0.25 mm.).

7) *Nonion pacifica* (Cushman) of Cushman (1934): Originally, Cushman used this name, as *Nonionina umbilicatula* var. *pacifica*, in describing a form from shallow water off Samoa. He distinguished it from *Nonionina umbilicatula* by its more compressed test and the absence of limbation. I have compared the holotype of this form with *Nonion affine*, and I find that they are very similar. I refrained from considering it a synonym only because of my resolve to include in the synonymy none but forms concerning whose identity there is no question. It is very probably a local ecologic variant of *Nonion affine*. The close proximity of this form to *Nonion affine* is indicated by the fact that, after its elevation to specific rank by Cushman, some of his subsequent identifications of "*Nonion pacifica*" in reality refer to *Nonion affine*. The present citation is such an example. The hypotype from the Pliocene of Fiji mentioned above was compared with topotypes of *Nonion affine*, and I was unable to find the slightest difference between them.

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8) *Nonion nicobarens* Cushman, 1936: This species represents an obviously erroneous determination. The founder compares it with *Nonion soldanii* (d'Orbigny), and writes that it has a "less prominent umbilical opening, larger number of chambers, and more compressed test." All of these features are correctly described, but they correspond exactly with the description of *Nonion affine*. A comparison of the specimens confirmed this, as not a single distinction could be found.

9) *Nonion pompilioides* (Fichtel and Moll) of Cushman (1936): The hypotype on the slide is labelled *Nonion pompilioides*. In publication this form was called "*Nonion pompilioides* (Fichtel and Moll) var." This specimen is identical with the topotypes of Reuss' species in the Cushman Collection.

10) *Nonion affinis* (Reuss) of Kleinpell (1938): Kleinpell's hypotype corresponds exactly with the topotypes of *Nonion affine*.

11) *Nonion pacificum* (Cushman) of Cushman and Todd (1945): The hypotype is similar in all respects to the topotypes of *Nonion affine*.

12) *Nonion planatum* Cushman and Thomas of Cushman (1948): Again in this case, the hypotype is identical with *Nonion affine*.

13) *Nonion cf. barleeanum* (Williamson) of Parker (1948): The hypotype is slightly larger (longer diameter 0.4 mm.) and probably somewhat thicker, and thus it is identical with the form encountered by Seguenza. But these are very unimportant characters, and because in all other features it is exactly similar to the topotypes of *Nonion affine*, I have no hesitation in considering it as belonging to that species.

14) *Nonion nicobarens* Cushman of Bermudez (1949): The hypotype differs in the somewhat greater thickness of the last two chambers and in having fewer chambers in the last whorl (only nine). These features represent a slight similarity to *Nonion pompilioides* (Fichtel and Moll), but other specimens from the same material of Bermudez and also labelled by him as *Nonion nicobarens* appear to be typical *Nonion affine*, although of somewhat larger size (longer diameter 0.35 mm.).

15) *Nonion umbilicatum* (Walker and Jacob) of Said (1949): The hypotype is similar to typical *Nonion affine* except that it is somewhat larger, as is "*Nonion nicobarens*," cited above.

16) *Nonion vicksburgense* Todd, 1952: The author writes: "The species differs from *Nonion affine* (Reuss)

in the less compressed test, the slightly fewer and less distinct chambers, and the irregular broken appearance of the umbilici as compared to the smoothly finished umbilicus in *Nonion affine*. It differs from *Nonion planatum* Cushman and Thomas in its larger size and irregular umbilici, and its slightly inflated later chambers." All of these insignificant differences are very difficult to see when one compares the holotypes of *Nonion vicksburgense* and *Nonion planatum* with only one topotype of *Nonion affine*; but when many specimens of each form are examined (paratypes of the former two and all of the topotypes of *Nonion affine*), we cannot separate them from each other. I feel certain that *Nonion vicksburgense* is a synonym.

17) *Nonion barleeanum* (Williamson) of Crouch (1952): Crouch's hypotype differs from topotypes of *Nonion affine* only in having thicker sutures and a "sutural ring" around the umbilical cavity. As stated above, this feature is not constant and varies considerably. Among the topotypes of *Nonion affine* there are some with the same character.

18) *Nonion formosum* (Seguenza) of Phleger, Parker and Peirson (1953), and *Nonion formosum* (Seguenza) of Parker (1954): The hypotypes of these two forms correspond exactly with the topotypes of *Nonion affine*. I have no hesitation in referring them to this species.

This recitation of cases may be rather tedious, but it is a necessary part of this article. It seems impossible to consider any of the cited minor differences as sufficient even for subspecific separation. Without doubt, these differences can all be included within the limits of natural variation of a single species, that is, all are of purely intraspecific character. Furthermore, we can even consider this species relatively quite constant in its morphologic features.

The arguments given above might have been more convincing had they been supported by statistical data such as measurements. When there are real differences between species, statistics are of great importance, but an attempt to apply them in this case seemed unnecessary, as the material listed obviously belongs to one species.

In spite of the very constant character of this species, six different "new species" were established for it and it was called by ten different names, all in the collections of one institution. I have no doubt that many more names could also be included if other collections throughout the world were revised. The collections of the United States National Museum are comparatively rich, but they represent

only a small part of all of the types described in all countries since the scientific study of foraminifera began. It is difficult to imagine how many "species" have been established throughout the world for other forms that are even more variable, such as, for example, species of *Cibicides* or *Discorbis*.

During the course of this revision, in addition to the forms which I have included above in the synonymy of *Nonion affine*, I also encountered many other types that are very similar to this species, which, after comparing the specimens, I place in two other lists of synonyms. The citations, together with data referring to age, locality and catalogue number, are given below, but they are not discussed as was done in the case of *Nonion affine* (Reuss). In order to save space, they are not presented in the usual style of synonymy, but are listed in paragraph form.

The first list of synonyms is as follows: *Nonion pompilioides* (Fichtel and Moll) [Pliocene, Corocina, Italy; topotypes (and hypotype), Cushman Coll., no. 46452]; *Nonion soldanii* (d'Orbigny) [Tortonian, Nussdorf, Austria; topotypes, U. S. Nat. Mus. Coll., no. 549139]; *Nonion halkyardi* Cushman [Eocene, Biarritz, France; holotype and paratypes; Cushman Coll., nos. 23224-23225]; *Nonion agrestum* Cushman and Stevenson [Miocene, Ecuador; holotype and paratypes, Cushman Coll., nos. 57741-57742]. The main difference between *Nonion pompilioides* and *Nonion affine* is the increase in the width of the last three to five chambers and the somewhat coarser perforation in *Nonion pompilioides*.

The second list of synonyms is as follows: *Nonion barleeanum* (Williamson) var. *inflata* van Voorthuysen [Pliocene, Netherlands; U. S. Nat. Mus. Coll., no. 549138 (two years later this name was changed by its author to *Anomalinoides barleeanum* (Williamson) var. *zaandamae*)]; *Nonion barleeanum* (Williamson) [Recent, North Atlantic; hypotype, U. S. Nat. Mus. Coll., no. 28112]; *Nonion zaandamae* (van Voorthuysen) [Recent, North Atlantic; hypotypes, U. S. Nat. Mus. Coll., nos. 2027, 2028, 2816, 2817 (not 28115)]. All of these specimens, and especially the latter two, differ from *Nonion affine* in having thicker sutures and somewhat coarser but less dense perforation.

In reality, the forms in both lists of synonyms are very close to *Nonion affine*, but without a detailed study of the morphology of their tests as well as their habitat, it is difficult to judge this relationship. It is possible that they represent three subspecies of one species, the nominal subspecies of which, according to the Law of Priority, should have the name given by Fichtel and Moll. Thus we would have

Nonion pompilioides pompilioides (Fichtel and Moll), *Nonion pompilioides affine* (Reuss), and *Nonion pompilioides zaandamae* (van Voorthuysen). But this is only supposition, and without further study I do not consider it possible to make any change in the synonymy of *Nonion affine* (Reuss) given above.

The well-known species *Nonion barleeanum* (Williamson) is also very close. I did not include it in the synonymy of *Nonion affine* (Reuss) or in that of the other forms only because I had neither the original material nor topotypes. There was also a very great temptation to call the form discussed above *Nonion umbilicatum* (Walker and Jacob), as was done by Said (1949) (see the citation in the synonymy of *Nonion affine*). I do not consider this procedure correct, however. That name cannot be accepted because the figure given by its authors represents a test which is evidently not symmetrical on the two sides.

GENERAL CONCLUSIONS

We have seen how many synonyms were discovered by a revision of the types of one small group of Nonions. My placing many well-known and often used specific names in synonymy may arouse some distrust on the part of my colleagues. The present study was carried out with as much accuracy and impartiality as was possible, but if others disagree I can only suggest that they re-examine these types and make their own revisions. I believe that the results would not be very different. I had an opportunity to show all of the types of these synonyms of *Nonion affine* to Dr. A. R. Loeblich, and I requested him to verify them as thoroughly as possible. After studying them he came to the same conclusions, namely, that they all belong to the single species *Nonion affine*.

I shall not attempt to discuss here the reasons for each of the incorrect determinations cited above. The reader can judge for himself to which of the four causes listed at the beginning of this article these misidentifications should be ascribed. It appears that in the majority of cases the real reason was a "too narrow" interpretation of the species concept. I believe that a similar detailed revision of other material in the Cushman Collection and United States National Museum collection of foraminifera, as well as in other museums elsewhere in the world, would make it possible to suppress many other specific names as synonyms. It is a work of great importance and urgency, for how can we compare Recent faunas from different areas, or correlate fossil material, if our identifications and faunal lists are not correct?

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In general, foraminifera are known as variable organisms. This appears to be true. Minor changes in ecological conditions can result in changes in the morphologic features of their tests. Loss of ornamentation, change in the character of the perforation, increase or diminution in the size of the whole test, and even (in a brackish-water environment) differences in the character and location of the aperture often originate in this way. It is my belief that such characters can sometimes, under certain conditions, become inheritable. I agree with Vinogradov (1952), who expressed this idea in describing the influence of trace elements on lower plants. But in spite of the fact that these differences are large, all of these variants are very often connected by transitional forms, indicating that they are of intraspecific character only.

I have observed this phenomenon rather often during the past eight years while studying the Recent foraminiferal fauna of many samples from the continental shelf from Cape Horn (lat. 56° S.) to Cabo Frio (lat. 23° S.). It is probable that if specimens of one of these variable species had been taken from the two extremes of this region, and if samples from the area between the extremes had not been seen, it would have been concluded that they belong to two different species. As more material becomes available for study, the true picture of intraspecific variation will become clearer.

On the other hand, some foraminiferal species are extremely constant, in spite of great differences in the ecological conditions of their habitats. We have already seen an example of such a very constant species in *Nonion affine*. It persisted through a long interval of geologic time, from the Eocene to the Recent, without change in any of its morphologic features, and it is now encountered in shallow water off Brazil, as well as in the greater depths of the Atlantic Ocean. Recent specimens compared with topotypes of Reuss' species do not show any differences except shade of color. Morphologically they are entirely identical.

I am deeply convinced that, in general, foraminiferal species are considerably more tolerant of changes in their environment and that their intraspecific variations are much wider than is usually admitted by the great majority of modern students of this group. In other words, what are now considered to be different species are in many cases actually only intraspecific variants, which are not sufficiently different even for subspecific separation. Because we have not yet found the intermediate

forms, we have been obliged to consider them independent species and to give them different names. Subsequent studies, therefore, not only result in the discovery of new forms and an increase in the number of species, but also should result in the discovery of transitional forms and thus a decrease in the number of species.

PROBLEMS AND PROPOSALS CONCERNING TAXONOMIC UNITS

We now come to another problem. In the discussion of taxonomic units given above, we have considered the problem in the light of strict application of the International Rules of Zoological Nomenclature, but we have neglected practical considerations that are of primary importance in applied paleontology and zoology. If we name only specific and subspecific taxa, we shall not be able to refer to many small changes which, although not even of subspecific value, can be very useful in stratigraphic and ecologic applications. This means that taxonomic ranks lower than the subspecies are necessary in our work.

Many zoologists and paleontologists have made various proposals, used different categories, and expressed diverse opinions. Micropaleontologists have taken an extremely small part in these discussions, although (as I wrote in an earlier communication) for many reasons their opinions should be even more interesting and valuable than those of others.

I believe that in our work we can accept two units lower than the subspecies, namely, the "variety" (*varietas*) and the "form" (*forma*). Both of these units are to be interpreted as having no valid status and thus not in conflict with the existing International Rules of Zoological Nomenclature.

A subspecies should have well-defined features and more or less definite and restricted stratigraphic and zoogeographic distribution. A variety also has some (usually only a few) characters which result from the influence of the environment, but they are not as distinct, and the geographic or stratigraphic distribution of a variety is not well defined. As has been expressed very well by one paleontologist, the variety is a category which is useful at the beginning of a study, when the student is not yet able to recognize whether the form can be considered a subspecies or represents only a small local differentiation. Subsequent investigation with new data should resolve such a question. Under the present proposal, if a new name is given to the variety, its founder cannot lay claim to the Law of Priority. This means that if another worker describes it in more

detail as a subspecies, he may either suppress the name of the variety as a synonym, or he may accept the older name of the variety if he desires. Only the name applied to the subspecies has validity, however, and is protected by the Law of Priority.

This category is probably more useful to paleontologists than to zoologists. Those who work with Recent material can easily ignore the category "variety." But, as with all taxonomic units, its concept and usage should be the same both in paleontology and zoology, and certainly no differences in its application can exist. In other words, if a zoologist finds the varietal category useful, he should be able to use it in the same way as a paleontologist.

It is otherwise with the category "forma." This category could be very useful in the work of paleontologists as well as in that of zoologists. This is the smallest category with so-called "directed variability," which is the opposite of "non-directed variability," or the individual variation shown by each specimen. A "forma" usually shows one unimportant but often clearly visible feature, which is not constant and can easily be lost. Furthermore, it has no definite region of distribution — its representatives are usually scattered. Both characteristics are equally important. The name of a "forma" should certainly be written without an author's name, and preferably as a clearly descriptive word, for instance: *glabra* (hairless, bald), *costata* (ribbed), *elongata* (elongate), *parva* (small), etc. The name should always be in the feminine gender.

In working with a fauna, especially with rich Recent material, we often see variability of form that should be considered under the category "forma." For example, in 1929 Cushman and Wickenden encountered specimens of *Bulimina patagonica* d'Orbigny (which usually has spines on the first half of its test) without these spines, and separated them as *Bulimina patagonica* var. *glabra*. In many places on the Patagonian shelf (the type locality of *Bulimina patagonica*), I have found small populations or single specimens of the same form, which were either scattered among typical *Bulimina patagonica* or more or less isolated in very small areas. As a rule, their numbers increased in places with unfavorable ecological conditions. Certainly this change (loss of spines) does not fulfill the requirements for a subspecies or even for a variety concept, but the category *forma* is here quite apt. In no other way can this small difference within the species be expressed, although it has importance as evidence of impoverishment in the living conditions.

Many other species lose or decrease their ornamentation under unfavorable ecological conditions.

And now let us summarize and make some practical suggestions. At present the nomenclature of the foraminifera is extremely overloaded with synonyms. The continuous increase in the number of invalid names may cause this branch of zoology (or paleontology) to lose its importance as a science and the foraminifera to lose their significance as stratigraphic guide fossils. We should now begin the "salvation" of our science, which may be done in two ways: 1) By cleaning our existing nomenclatural household; and 2) by being extremely careful in the publication of new names (new species or new subspecies).

In order to accomplish the first task, I would like to suggest that all students of foraminifera who have the opportunity should spend some time studying the collections of the United States National Museum in Washington, and, whenever possible, take time from their special studies for a revision of some published material (types). I refer to the United States National Museum because at present the richest depository of type material in the entire Western Hemisphere is concentrated there, and a revision based only on bibliographic data, without the types, has almost no value. The Eastern Hemisphere has its own centers of rich collections. To fulfill the second task, let us have much more respect for the laws of biology and the International Rules of Zoological Nomenclature.

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“Taxonomy of the Globotruncanidae” — Remarks

PAUL BRONNIMANN AND NOEL K. BROWN, JR.

Esso Standard Oil, S. A.
Havana, Cuba, and
Gulf Oil Corporation
New York, N. Y.

Some points of controversy concerning our study “Taxonomy of the Globotruncanidae” (1956, pp. 503–562) have recently been raised by Reichel in his latest news report to MICROPALAEONTOLOGY (1957, pp. 92–94), and by Dalbiez in his restudy of *Rotalia deeckeii* Franke (1957, pp. 187–188). Reichel (op. cit., p. 93) describes this study by Bronnimann and Brown (1956) as “...an interesting attempt to unite with the Globotruncanas pelagic foraminifera from the Upper Cretaceous which are clearly related to them by their involute coiling, their apertures, and their ornamentation.” This description implies that the globotruncanids are not pelagic foraminifera. This is not the opinion of Bronnimann and Brown. On the contrary, we believe that globotruncanids are pelagic foraminifera, and we have so stated (1956, p. 503) in our study. The reference to “involute coiling” must be a *lapsus calami*. Apparently what Reichel means to say is that globotruncanids seem to have “*Globigerina*”-like ancestors, as implied by the similarity in coiling, apertures, and ornamentation.

The controversial points are sources of misunderstanding. For this reason, and because we do not agree with the views expressed by Reichel (1957, pp. 93, 94), it seems worthwhile to discuss them more thoroughly.

(1) Bronnimann and Brown observed that the test-wall of the globotruncanids is granular, in the older primitive forms rather coarse, in the younger advanced forms relatively fine microcrystalline. This was assumed by Reichel to conflict with the observations of Wood (1949, p. 250), who cited two of the more advanced species, *Globotruncana linneiana*

and *Globotruncana cretacea*, as possessing radiate perforate test-walls. The conflict is rather a difference in terminology. That a globotruncanid test-wall exhibits varying degrees of granularity (in the sense of Bronnimann and Brown) does not preclude its being also radiate perforate (in the sense of Wood). Wood himself was caught in the different usages, for, according to Wood and Haynes (1957, p. 46), “The type species of *Cibicides*, *C. refulgens* (Montfort), was erroneously stated to have a granular wall structure in 1949. Thin sections show the structure to be radiate; the individual crystals being apparently larger than usual.” Since the test of all globotruncanids is composed of radially arranged calcite crystals, a black cross will appear in polarized light. Reichel concedes but does not explain an “external granulation,” implying that it is only “skin deep,” and that any other type of granulation is the result of recrystallization. Granted that tests may have become recrystallized in some occurrences, it seems too much to invoke recrystallization as the cause of the granular appearance of tests of globotruncanids whether found in Italy, Switzerland, Austria, Spain, Cuba, Texas, or California, and especially since they accompany, in some instances, other microfossils, such as lagenids and ostracodes, which show no signs of recrystallization (or granular appearance). The “external granulation” is merely the appearance that the granular test-wall presents on the surface.

(2) Reichel has attempted to show that our distinction between *Rotalipora* and *Thalmanninella* is not so clear cut because in thin sections of vertically cut specimens both appear to be imperforate in the umbilical region. As a matter of fact, we (1956, p. 536) stated that we knew of no sure way to

distinguish vertically cut specimens of these forms. All globotruncanids with keeled imperforate peripheral bands, whether or not they have umbilical cover-plates, are imperforate in and around the umbilicus, since the peripheral band is coextensive with the septal face which extends into the umbilical region. But this does not represent an umbilical cover-plate which is developed in some keeled forms and in some forms without keels. It is also imperforate but is a more confined structure than the septal face. Reichel points out that *Rotalipora appenninica* (O. Renz) has intra-umbilical apertures in the early chambers of the last whorl, and therefore assumes that *Rotalipora* and *Thalmanninella* are closely related and had a common origin. We believe this too, but we also believe that *Thalmanninella* and *Rotalipora* are to a rather close degree homeomorphic forms of different lineages from the same stock. We do not agree with Reichel that *Rotalipora* is derived from *Thalmanninella*. Since *Rotalipora* and *Thalmanninella* are closely related, it is not unusual that they should exhibit similar morphologic characters which have been developed in more or less parallel trends. Toward the end of each lineage the accessory apertures tend to move radially outward away from the umbilicus. In the lineage ending with *Thalmanninella*, the accessory apertures never get completely out of the umbilicus, whereas in the lineage ending with *Rotalipora* the accessory apertures are sutural and at least some are well out from the umbilicus.

(3) According to Reichel, the usage of the term "supplementary openings" should be reserved for a second opening in any chamber. As a matter of fact we (passim) used the term "accessory apertures," not "supplementary openings." Pores, of course, are openings, but apparently Reichel restricts openings to apertures. Nevertheless, he notes that "openings" in *Globotruncana* as figured by Reichel (1950, text-fig. 7b) and refigured by Bronnimann and Brown (1956, text-fig. 7) are not "supplementary openings." He then eliminates any apertures at all in the specimen by stating that "no other openings can be seen" in it. This seems to be another *lapsus calami*, for the specimen is obviously not without apertures.

(4) Without offering a reason, Reichel states that our identification of *Thalmanninella ticiensis* var. *alpha* (Gandolfi) [now called *Globotruncana* (*Thalmanninella*) *ticiensis subticiensis* by Gandolfi (1957, p. 59)] with *Thalmanninella multiloculata* (Morrow) does not seem well founded. It is true that the holotype of *Thalmanninella ticiensis* var. *alpha* differs from the holotype of *Thalmanninella multiloculata* in exhibiting a more strongly keeled peripheral band and in possessing ten chambers in the last whorl as

compared with eight in *Thalmanninella multiloculata*. However, differences can be found between any two specimens. No limits of intraspecific (or intrasub-specific) variability of the two forms have been demonstrated. Neither form has a keeled imperforate peripheral band in all chambers following the "*Globigerina*" beginning. Reichel, who would separate the two forms by the outmoded typological method, ignored our remarks (1956, p. 535) on *Thalmanninella multiloculata*: "We have made the description of this species rather broad to include the *Thalmanninellas* which have an incipient keeled, imperforate, peripheral band barely discernible only in the first chamber following the '*Globigerina*'-beginning to those *Thalmanninellas* which have a well-marked keeled, imperforate, peripheral band in all chambers except the final one following the '*Globigerina*'-beginning. Between these two forms all transitions can be found. We can split degrees, but in this case it seems practical not to establish a taxon for a *Thalmanninella* which has all chambers following the '*Globigerina*'-beginning keeled except the last two, another taxon for a *Thalmanninella* which has all chambers following the '*Globigerina*'-beginning keeled except the last three, and so on."

(5) Reichel has questioned the synonymy of *Praeglobotruncana stephani* (Gandolfi) and *Praeglobotruncana delrioensis* (Plummer). He points out that the holotype of *Praeglobotruncana delrioensis* is less conical than *Praeglobotruncana stephani*. We do not disagree here, but if one is to make a separation on this basis, it is necessary to know to what degree a specimen is conical before it is assigned to one or another taxon. We refer to our remarks under (4). How much less conical must a specimen be to be entitled to the name *Praeglobotruncana delrioensis*, and how much more conical must it be for it to be called *Praeglobotruncana stephani*? Furthermore, how much more conical still must it be for it to be called *Praeglobotruncana stephani* var. *turbinata* (Reichel)?

Dalbiez (1957, pp. 187-188) has made certain statements which we feel obliged to set right:

(1) He (1957, p. 187) states: "Bonnimann and Brown (1956) showed that *Globorotalia greenhornensis* Morrow... is conspecific with *Thalmanninella brotzeni*...." We did not show that *Thalmanninella brotzeni* Sigal was conspecific with *Thalmanninella greenhornensis* (Morrow); we (1956, p. 536) merely said that it may be.

(2) Dalbiez (1957, p. 187) "does not agree with Bronnimann and Brown when they suggest that *Thalmanninella ticiensis* (Gandolfi) and *Rotalipora appenninica* alpha (Gandolfi) are the same as *Thalmann-*

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inella greenhornensis." This statement is only partly correct. We (1957, p. 536) did suggest that *Thalmanninella tycinensis* may be the same as *Thalmanninella greenhornensis*. However, concerning the form called *Rotalipora appenninica alpha*, we (1957, p. 536) merely stated that it was the *Thalmanninella* most closely resembling *Thalmanninella greenhornensis*.

(3) According to Dalbiez (1957, p. 188), "... Reichel's 1950 classification, that is, with *Globotruncana* and *Rotalipora* as genera and with *Ticinella* and *Thalmanninella* as subgenera of *Rotalipora*, should be retained." Reichel did not classify these forms in this manner. In Reichel's classification (1950, p. 600), there is only one genus, *Globotruncana* s.l., and four subgenera, viz. *Globotruncana* s.s., *Rotalipora*, *Thalmanninella*, and *Ticinella*.

(4) The following statement by Dalbiez (1957, p. 188) is obviously confused *per se*: "... the writer wonders how *Rotalipora appenninica* could have originated from *Praeglobotruncana delrioensis* (Plummer) (= *Globotruncana stephani* Gandolfi, 1942). This suggestion by Bronnimann and Brown does not appear logical when one considers that *Praeglobotruncana delrioensis* appears stratigraphically before *Rotalipora appenninica*."

(5) According to Dalbiez (1957, pp. 187-188), "Early forms of *Rotalipora*, such as *Rotalipora appenninica alpha*, possess thalmanninelloid apertures. These accessory apertures open into the umbilicus, and it is only in later species [of what?] that they migrate into the sutures. This observation reinforces the theory, disputed by Bronnimann and Brown, that *Rotalipora* evolved from *Thalmanninella*." *Rotalipora appenninica alpha* possesses "thalmanninelloid apertures" because it is a *Thalmanninella*. Besides,

Dalbiez' observation does not reinforce the hypothesis that *Rotalipora* evolved from *Thalmanninella*. It only repeats Reichel's contention which is discussed above, and it simply indicates that an advanced *Thalmanninella* evolved from a primitive *Thalmanninella*. In dismissing Bronnimann and Brown's suggestion that *Rotalipora* evolved from *Praeglobotruncana* rather than from *Thalmanninella*, Dalbiez (1957, p. 188) has found that he is left with an admittedly unsatisfactory phylogeny, from a *Thalmanninella* to a *Rotalipora* and back to a *Thalmanninella*.

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ABSTRACT: *A microcapillary tube attached to a Leitz mechanical stage and mounted on the stage of a microscope provides a simple method for single-mounting microfossils. This technique makes it possible to sort and mount large numbers of fossils in a short time, in either glycerine jelly or Canada balsam.*

A micromanipulator for single-mounting microfossils

ROGER Y. ANDERSON

*University of New Mexico
Albuquerque, New Mexico*

INTRODUCTION

Two standard pieces of equipment, a microscope and a mechanical stage, can be combined with a microcapillary tube to produce a device for making single-grain preparations of various types of microfossils. Pollen, spores, hystrichospherids, diatoms or other small fossils are dispersed in a liquid on a microscope slide, and one specimen is drawn up into the capillary tube. The specimen is then discharged from the tube onto a new slide and covered with a mounting medium and cover-slip. Microcapillary tubes have been used in handling diatoms for many years, and Faegri and Iversen (1950) described their use in mounting pollen grains. The most popular technique in current use involves some type of "fishing" operation such as those described fully by Klaus (1953) or Mädler (1956). The capillary method is more rapid and versatile than "fishing"; it can be used with an ordinary biological microscope in which high-power magnification is available; and it can be used for making semi-permanent mounts in glycerine jelly or permanent mounts in Canada balsam.

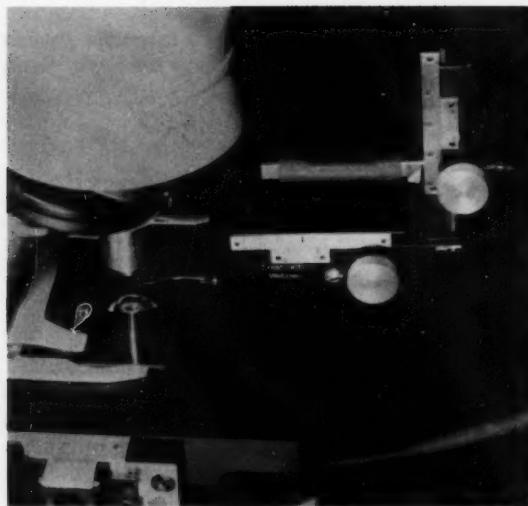
EQUIPMENT

The necessary equipment includes a microscope with a large stage that can accommodate a mounting bracket, in the present case an American Optical "Microstar" model; a small mechanical stage of the type generally used with petrographic microscopes, in the present case an Ernst Leitz compound stage (PIRUX); 4 mm. or 5 mm. glass tubing; and 1/8 inch and 3/16 inch bore rubber tubing. The mechanical stage is firmly bolted to the stage of the microscope in the position indicated in text-figure 1. The upper slide-holding arm of the Leitz mechanical stage is removed, and the glass tubing is held in place on the lower slide-holding arm by slipping a short piece of 3/16 inch bore rubber tubing over both the glass tube and the lower slide-holding arm. The flexibility of this type of mounting is an advantage in that the position of the capillary is easy to adjust, and the capillary is less likely to break when touched to the microscope slide. The capillary tube must be

mounted on the mechanical stage in a position that will give ample clearance for the revolving objectives of the microscope. Before the glass tubing is mounted on the mechanical stage, the tip is drawn out into a microcapillary tube. Great care must be used in this operation, and the shape of the tube will depend on the type of mounting. The very tip of the tube must have a downward deflection, as shown in text-figure 2. The size of the opening at the end of the tube should be about 100 microns for most microfossil work. The broken tip of the microcapillary tube should be ground on a lap with a fine abrasive. Best results were obtained by grinding on the upper and lower surfaces only (text-figure 2). If the angle of tube deflection is too great, the specimen will be obscured, and if the angle is too small, the surface-tension disturbance caused by the tube as it contacts the oil or glycerine will make the specimen difficult to control. After the capillary tube is mounted on the mechanical stage, a long piece of 1/8 inch bore rubber tubing is attached to the large end of the glass tube in front of the microscope, and brought around to the back. The end of the rubber tube is then placed in the worker's mouth, and by blowing or sucking on the tube the worker can control the movement of oil or glycerine in the microcapillary tube.

MANIPULATION AND MOUNTING

The sample is dispersed in a thin film of glycerine or oil on the microscope slide and placed under the low-power objective (10 \times) of the microscope. The desired specimen is placed in position in the middle of the field of view. At this stage in the operation, higher magnification can be used to verify the suitability of the specimen. With the low-power objective in position, the two adjustments on the Leitz mechanical stage serve to move the capillary tube into position. At this point the shadow of the tube can be seen through the ocular. The final placement of the tube is accomplished with the vertical adjustment, the tube being lowered until it touches the fluid just in front of the specimen (text-

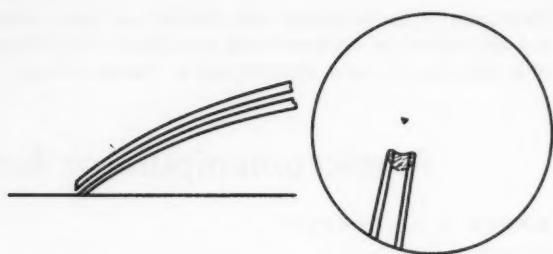


TEXT-FIGURE 1

Leitz mechanical stage and microcapillary tube in position for picking up a specimen.

figure 2). At this instant the fluid will move into the tube and carry the specimen with it. The rate of movement of the fluid tends to be rapid, but it can be controlled in several ways. The movement can be slowed down by lightly blowing into the rubber tubing or by drawing a long column of oil or glycerine into the microcapillary prior to picking up the specimen. After the specimen has moved into the opening, the capillary tube is raised from the fluid with the vertical adjustment. The slide with the dispersed sample is then moved out of position and a new slide is placed under the objective. The tube is again lowered until it contacts the slide, and the specimen is ejected by blowing into the rubber tubing. The slide now bears a droplet of oil or glycerine containing the specimen. A single drop of mounting medium is placed on top of the droplet and covered with a cover-slip. If the drop of mounting medium is placed on the cover-slip first, and the cover-slip is then placed over the droplet, the specimen will remain near the center of the preparation. The location of the single specimen in the preparation may be facilitated by picking up and discharging extraneous matter that is in the residue with the specimen. This material will disperse after the cover-slip is applied, thus helping to mark the position of the specimen.

Semi-permanent mounts are made by dispersing the sample in glycerine and using glycerine jelly as a mounting medium. Permanent mounts are made by washing the sample in xylene and dispersing in a heavy, clear natural oil that is soluble in xylene



TEXT-FIGURE 2

Specifications for shaping and grinding the tip of the microcapillary tube.

and has a suitable index. Crown immersion oil has been found ideal for this purpose. The oil droplet containing the specimen is then covered with a drop of Canada balsam and placed on a low-temperature hot plate.

The microcapillary technique makes it possible to single-mount large assemblages rapidly. The system found most useful is as follows: Several passes are made over the slide bearing the dispersed sample under low ($10\times$) magnification and with the capillary tube in position. Each new specimen that is encountered is picked up in the tube. After twenty or thirty specimens have been picked up, the slide bearing the dispersed sample is moved out of position and a row of new slides is placed in position near the objective. As each of these slides is moved under the objective, a specimen is ejected from the tube. After all of the specimens have been ejected, the twenty or thirty slides bearing single specimens are each covered with the mounting medium. After two or three such passes, a fair representation will have been mounted. Subsequent specimens are then picked up after being located and examined under higher magnification. In a similar manner, paratype slides are easily prepared by scanning and picking specimens of the same type and ejecting all of them onto one or onto separate slides.

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Locating plant microfossils on mixed slides

ALFRED TRAVERSE

Shell Development Company

Houston, Texas

In work with fossil pollen and spores it is necessary to be able to find quickly the items that have been selected as typical examples of a certain kind of fossil. Also, for comparison of microfossils in the course of study and identification, it is essential to be able to locate previously studied items that need to be compared.

Faegri (1939) and later Klaus (1953) described techniques for preparation of slides containing isolated single specimens. Such single-grain preparations are excellent for any specimen that will be permanently preserved, and especially for type specimens used in published descriptions and hence intended for deposition in a public collection.

However, in the routine work of making macerations of sediments, mixed slides comprise the overwhelming bulk of slides used. Some of the items on such slides must inevitably be referred to in reports, publications, and in correspondence concerning sample slides sent to other palynologists. Unfortunately, the mechanical stages of microscopes are not standardized. The references in certain papers to location, e.g., 35.6×106.8 , are meaningless, and are only slightly better if stated "35.6 \times 106.8 on Zeiss microscope AB-1, at the Yogurt Laboratory." If one can get a conversion factor from that microscope to one's own instrument, the items can be found, but this is not often practical. The use of conversion factors is complicated by the unfortunate circumstance that the scales on different mechanical stages sometimes run in opposite directions. Direct conversion of stage readings is complex in such instances.

Loose (1934) described a method of using a location-finder, i.e., a prepared grid-slide with a system of engraved quadrats. Location of items on mixed slides can be given in terms of the quadrats on the standard grid-slide. Anyone with a grid-slide identical to the one used in a description provided for a fossil can locate the item again. Similar location-finders are on the commercial market. These have

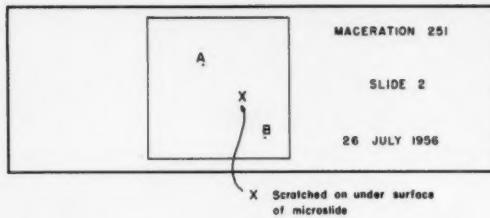
the disadvantages of not being very precise and of introducing an additional step requiring a piece of equipment that must be identical to the one used in the original description.

Any method that provides for location of microfossils without reference to another microscope or to anything not contained in the slide itself is much better. An example is a marking technique for circling an area on the coverslip above the indicated item. Ink, grease pencil, and diamond markers are used for this purpose. All of the marking techniques have disadvantages. The circles are too large and hence often enclose several microfossils. The circles themselves sometimes obscure other items, and when many items must be located on one slide, it is troublesome to identify the various circles, and there may be difficulty with their overlapping.

The following technique is a modification and improvement of one described by Traverse (1955). It provides for the location of any item on a microslide by reference to a fixed point on the slide. In order to find any object on a slide, the only requirement is that a microscope with a mechanical stage reading in millimeters be available; a description of the location derived from any other microscope can be used.

A small, fine "x" is scratched on the under side of the slide with a diamond pencil. This "x" can be located in the center of the slide by ruling the "x" with a straightedge oriented from corner to corner. This refinement is not necessary, but does make it easy to find the "x". The location of any microfossil on the slide can then be given in millimeters above or below and to the right or left of the "x". The center of the "x" is brought into focus and centered in the field of the microscope at about 150 diameters magnification, and the reading on the mechanical stage is recorded. The fossil is then located and its reading taken. Subtraction gives the coordinates for the fossil from "x." Anyone with any conventional mechanical stage calibrated in millimeters can now find the fossil by locating the "x" on his microscope,

TRAVERSE



TEXT-FIGURE 1

Microfossils *A* and *B* can be located by coordinates, with reference to the center of the "x" engraved on the slide.

recording its reading, and computing the location of the fossil by adding or subtracting the coordinates given for it, according to the way his mechanical stage reads.

For example, on the slide shown in text-figure 1, the stage of the microscope used in the original work might read 39.7 (vertical scale) \times 99.3 (horizontal) for "x". Microfossil *A* might read 35.2 \times 105.4, and microfossil *B* 46.2 \times 96.1. The following data would then be given for location of the fossils:

Micro-fossil number	Slide number	Distance of fossil from point "x" on slide, in mm.	
		Vertical scale	Horizontal scale
<i>A</i>	Mac. 251-sl.2	up 4.5	left 6.1
<i>B</i>	Mac. 251-sl.2	down 6.5	right 3.2

If desired, an additional mark can be added as a check, if the obscuring of other fossils on the slide is unimportant. This can be done with one of the marking techniques mentioned above, or better, a tiny pointer can be cut from a gummed label and fastened to the slide. The fossil is brought into the center of the field at high-dry (about 500 \times) magnification, and the iris diaphragm of the condenser is closed down to provide a point of light on the slide. This provides the target for affixing the pointer. The objective is turned out of the way and the moistened pointer is put in place with a pair of forceps and a needle.

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A simplified method of grinding foraminifera

F. P. C. M. VAN MORKHOVEN
N.V. De Bataafsche Petroleum Maatschappij
(Royal Dutch/Shell Group)
The Hague, Netherlands

INTRODUCTION

The usual method of grinding foraminifera on a glass plate is fraught with a number of drawbacks and risks, which can be summarized briefly as follows:

- 1) No check can be kept on the process while the actual grinding is being carried out, so that no continuous observation of that part of the test which is being ground away is possible.
- 2) A considerable amount of time is wasted in constantly carrying the specimen to be ground to and fro between the glass plate and the microscope in keeping a check on the progress of the grinding operation.
- 3) In many cases the specimen is ground too far — a factor which, when only a few specimens are available, renders grinding risky and consequently inadvisable.
- 4) It is impossible to make curved or undulating ground surfaces, if it is desired to observe such surfaces as a whole.
- 5) It is very difficult to hold the specimen in the correct position during grinding; as a rule, this is more or less simply a matter of "feeling." The result is that, in many cases, an undesired oblique cut is obtained.

These difficulties and risks are obviated if foraminifera are ground by the method described below. In practice it has been found that the use of this method enables slides to be made more quickly and with better results. By this method, grinding can be carried out *directly under the microscope*. In principle, any microscope can be used for this purpose; it is, however, advisable to replace the glass plate on the microscope stage by a plate of non-rusting metal (for example, brass or copper), in which there is a circular hole about 4 cm. in diameter with the field of vision as center point.

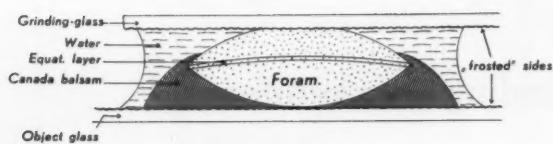
MOUNTING THE SPECIMEN

The specimen to be ground is transferred under the microscope from the collective slide to the center of the opaque side of an object glass ($77 \times 27 \times 1$ mm.). These object glasses are "frosted" on a glass plate by means of carborundum powder (for example, no. 220 or no. 300). A few small pieces of Canada balsam are then deposited near the specimen by means of a waxed needle.

For this purpose it is preferable to use xylol-free, hard Canada balsam, the advantage of which is the short time required to heat it and the fact that nevertheless it hardens immediately on cooling. Heating is effected by warming the object glass from below, through the circular hole in the microscope stage, by means of a small spirit lamp. It is possible to adjust the position of the specimen with the needle as soon as the Canada balsam is seen to melt. In this connection the surface to be ground for observation, e.g., the equatorial surface of an orbitoid, must be adjusted to a virtually horizontal position, whereas curved or undulating surfaces should preferably be mounted with the most convex side upward. In order to prevent crumbling away and to save time in grinding, the specimen must be firmly embedded in the middle of the Canada balsam, but nevertheless must not be deeply buried in it. Practice has shown that hard Canada balsam is often more difficult to grind away than the test itself. Accordingly, in mounting the specimen, a sufficient quantity of this balsam should be used, but particular care should be taken to avoid using too much (see text-fig. 1).

GRINDING

The grinding down, or rather filing down, of the specimen is done under the microscope with the rough side (i.e., the "frosted" side) of a second object glass. This glass is moved to and fro, or round and round, under gentle pressure, on the specimen, after having been previously moistened with water so



TEXT-FIGURE 1

that it becomes transparent at the point of contact with the specimen. *No carborundum powder is used in grinding!* Rough, medium fine, and fine frosted glasses can be used for grinding, one after the other, if desired and depending on the quantity of material to be ground away and the size and/or hardness of the specimen. These glasses are likewise made in the usual manner, with carborundum powders nos. 100, 220 or 300, and 500. The transparent nature of such glass "files" makes it possible to follow the grinding progress closely under the microscope, during which a clear, continuous picture is obtained of the structure of the disappearing part of the test.

The grinding plate is moved in a horizontal position until the ground surface to be observed has been completely or partly reached. By tilting the grinding plate more or less, any parts of the test which still have to be removed can then be ground away. The last vestiges of extraneous material, left behind in hollows in the surface to be exposed, can be scraped

away with a needle, the end of which has been ground into triangular form for this purpose. In this manner even markedly curved and undulating surfaces can be completely exposed.

The material which has been ground and scraped off is removed with a brush dipped in water; the grinding plates should also be rinsed in water occasionally. Accumulation of Canada balsam grindings cause the latter to become somewhat dull in the course of time, and they should then be cleaned with xylol.

THIN SECTIONS

To produce a thin section, a specimen prepared in the manner described above should be heated under the microscope and then turned over. In this process, any cavities between the ground surface and the glass plate, especially in the case of curved or undulating specimens, should be completely filled with Canada balsam. The other half of the test is then removed in the manner described above. The round hole in the microscope stage makes it possible to study the slide by transmitted light. When making thin sections, it is best to carry out the final stage of grinding under transmitted light, as a precautionary measure. The finished slide is covered with a cover glass in the usual manner.

Instructions to authors

Much unnecessary work and expense can be avoided if a standardized procedure is followed in the preparation of manuscripts. With this in mind, the following suggestions are offered to authors.

FORMAT

Articles and news reports submitted for publication in *MICROPALEONTOLOGY* are to be typewritten on opaque, white, heavy-weight paper not less than 8×10 nor more than 8½×11 inches in size. Onion-skin and legal-size paper are too difficult for the editors and printer to handle, and in general will be returned to the author for retyping. The original copy of the paper must be submitted. We would also like to have one carbon copy for reference, but it cannot be used as copy for the printer.

The pages are to be numbered in sequence, and the author's name typed in the upper left-hand corner of each page. *All* copy, with *no* exceptions, is to be typed double-spaced. This rule includes the bibliography, the abstract, synonymy, quotations, tables, faunal lists, explanations of figures, etc. Standard-sized type (pica) is preferable to small type (elite or micro).

ABSTRACT

All papers except brief notes are to be accompanied by an abstract, which precedes the title of the paper and is entirely underlined for italics except for names of genera and lower categories, which are not to be underlined. The abstract should not exceed 60 or 70 words in length, and is to be in English regardless of the language employed in the paper itself. It may include names of genera or higher categories proposed or emended in the paper, but should not include lists of new species.

TITLE

The title of the paper should not exceed 75 characters in length, including punctuation and spaces. It is to be typed in capital and lower-case letters, capitalizing the initial letters of proper nouns only. It is indented five spaces from the left margin, and there is no period at the end. Do not underline any words in the title.

AUTHOR'S NAME AND AFFILIATION

The author's name is to be typed entirely in capital letters, beginning flush with the left-hand margin, below the title of the paper. Omit the word "by." Do not underline the author's name.

Following the author's name, his professional affiliation (or city of residence, if preferred) is typed in capital and lower-case letters, beginning flush with the left-hand margin and underlined for italics. In the case of joint authorship of a paper, the names of both authors are typed in capitals on a single line, with the word "and" also in capitals. The first author's affiliation is then typed in capital and lower-case italics, followed by the word "and" in lower-case but not underlined, and then followed by the second author's affiliation, underlined for italics. Each affiliation is to begin flush with the left-hand margin of the page.

SUBJECT HEADINGS

Subject headings should be limited to about 45 characters. Main headings are to be typed all in capital letters, subheadings in capital and lower-case letters, capitalizing the initial letters of proper nouns only. No words in the headings are to be underlined. All subject headings are to begin flush with the left-hand margin.

SYSTEMATIC HEADINGS

Systematic headings can be divided into "display" headings and headings for taxa that are described. Display headings do not refer directly to described taxa, but merely give the classification of a lower taxon that is being described below. Inasmuch as *MICROPALEONTOLOGY* covers both animal and plant microfossils, it is desirable to furnish the complete classification of the group or groups of organisms under discussion in the systematic section. Give at least the name of the phylum, class, order, family, genus, and subgenus (if any), each preceded by its appropriate word. The name of each genus and subgenus is to be accompanied by the name of its author and the date of original publication. Authors of higher taxa may be cited if desired; for species and lower taxa, cite the author but not the date in the heading. In all cases, the contributor must be responsible for the accuracy of the dates given and for the spelling of scientific names and names of authors, as the editors cannot be responsible for these matters for all groups of micro-organisms.

All systematic headings are typed centered on the page. In the display headings, the word that characterizes the taxon ("Class," "Order," etc.) is to be typed in capital and lower-case letters. The name of taxon itself is typed entirely in capitals. Names of authors are in all cases to be typed in capital and lower-case letters, and should be

written out in full, not abbreviated. No systematic headings are to be underlined in any case.

In the heading for a taxon that is described, the name of the taxon itself is to be typed in capital and lower-case letters, without underlining. This applies to taxa of any rank that are described. The author's name is typed in capital and lower-case letters, even if the taxon is new. When the taxon described is new, the author's name should be followed by the expression "new genus," "new species," etc., unless the paper is written in a language other than English. In the latter case, this expression may be given in the language of the paper or in the customary Latin abbreviation ("sp. nov.," "gen. nov.," etc.).

SYNONYMY

The form to be used for synonymy can be seen by examining previous issues of *MICROPALEONTOLOGY*. Note that the author of a systematic name is repeated with each subsequent citation of the name, and is typed in capital and lower-case letters, whereas the author of the particular reference being cited is typed entirely in capital letters. A dash is used to separate the author of the scientific name from the author of the reference being cited. In the reference in which a scientific name was first published as new, the author's name is typed in capital letters and is not repeated. The top line of each entry is to begin flush with the left-hand margin; subsequent lines of the same entry are indented.

USE OF ITALICS

In general, nothing is to be underlined for italics except the abstract, titles of papers in the bibliography, and the Latin names of genera and lower taxa when they occur in the running text, in the figure explanations, or in the synonymy. Nothing in the systematic headings is to be underlined. The use of italics for special emphasis in the text is discouraged, but occasional exceptions will be permitted.

ELIMINATION OF FOOTNOTES

Generally speaking, no footnotes are to be used. Explanatory or tangential remarks should be incorporated into the text; if they are too irrelevant to be incorporated, they can probably be omitted without harm. Footnotes are never to be used for references (see the following section).

REFERENCES

In the running text, bibliographic references are to be identified by citing the author's name, followed, in parentheses, by the date of his publication, with a page number if desired. References are to be cited in full only in the bibliography, at the end of the paper. They should not be given in footnotes. In the synonymy, use an abbreviated form of the reference, consisting only of the name and issue of a serial publication or a shortened form of the title of a book, plus the pages and figures referring to the organism in question.

BIBLIOGRAPHY

The form to be used in the bibliography can be seen by examining papers previously published in *MICROPALEONTOLOGY*. The actual year of issue of the paper cited should be given as the date of publication, below the author's name. Note that in many publications issued in parts, the parts do not always bear the same date as the year covered by the whole volume. Examples of this point are the "Eclogae," of which Number 2 of each volume is usually issued during the year following that of Number 1, and the Bulletins of the Société Géologique de France, of which parts of each volume are issued during two or more years.

The titles of articles or books are to be underlined for italics, and are to be typed in capital and lower-case letters, only proper nouns having an initial capital. The title ends with a period. For books, the place of publication follows the title, and is followed by a colon; after the colon, give the publisher, the volume number (if any), and the number of pages and plates.

For serial publications, the word order and abbreviations to be used are shown in the "List of Publications" and "List of Abbreviations" issued as part of Volume 30 of the *CATALOGUE OF FORAMINIFERA*. The place of publication is omitted in citations of serial publications except in cases of ambiguity or obscurity. Series, volume, and number or part are to be given, with the appropriate word abbreviated in each case ("ser.," "vol.," etc.). Exact pagination, plate numbers, and text-figure numbers for the article cited should be given.

STYLE

Long, involved sentences and parenthetical remarks should be avoided. *MICROPALEONTOLOGY* is an international publication, and not everyone can easily follow a highly complicated style in a language other than his own. Relatively short paragraphs are also desirable. Criticism of other authors' work or publications must be kept on an objective level. We will not serve as a vehicle for allegations or derogations between authors.

ILLUSTRATIONS

In general, plates are to have a white background. The finished size of the printed plates will be 7×9 inches exclusive of margins. Originals of plates should therefore be mounted on a field 7×9 inches in size if no reduction is desired. If reduction is desired, the width and height of the field must *both* be in proportion to these dimensions. Templates to be used as guides in mounting plates are available without charge from the editors, in the following sizes: 7×9, 9½×12, and 14×18 inches. Printed numerals and letters of standard size and form are also available; in requesting them, please state precisely which numbers and letters are needed, and the size of the original plate *before* reduction.

Photographs of all specimens except sections are to show the illumination as incident from the upper left side, as is conventional. Line drawings of specimens need not

show highlights, but if it is desired to indicate illumination, it is to be shown as coming from the upper left side.

Maps, tables, groups of drawings of specimens, and the like, which are intended for use within the text, are to be either 3 inches or 7 inches in width and not more than 8½ inches in length, after reduction. The originals must therefore be either 3 or 7 inches wide and not over 8½ inches long, or if reduction is desired, the length must be such that when the illustration is reduced to one of these widths, its length will not exceed 8½ inches.

All drawings must be in ink, on opaque white stock. Lettering on maps, graphs, etc., should be of such a size that it will be not less than 2 mm. high after reduction. Figures intended for use in the text should always be mounted on separate sheets, never incorporated into the text. The figure number and the top of the figure should be clearly indicated, preferably on the back of each illustration.

EXPLANATIONS OF ILLUSTRATIONS

An explanation must be furnished for every figure. The style for plate and text-figure explanations can be seen by examining previous issues of *MICROPALEONTOLOGY*. The explanation for each plate is to be typed on a separate sheet of paper, and the explanations for all the text-figures grouped together on another separate sheet. Figure explanations should not be cut into the text of the paper itself, nor typed on the same sheet as the il-

lustrations. The magnifications given in the explanations of plates and text-figures should be the eventual magnifications of the figures after reduction, but, in addition, a statement should be sent to the editors clearly indicating the original magnifications of the figures as submitted.

AUTHORS' ALTERATIONS

Authors should endeavor to make their copy as free from errors as is humanly possible. References to the literature, and statements of fact or opinion, should all be carefully checked before the manuscript is submitted. The editors will question discrepancies or correct obvious errors when they are observed, but they cannot be responsible for the overall accuracy of all papers published. Insofar as is feasible, minor changes submitted by the author will be made while a paper is in galley, but a charge will be made for substantial alterations requested by an author while his paper is in press.

L'ENVOI

In the interests of maintaining the editors' health and peace of mind, and especially of holding down printing costs (and thereby subscription rates), it is hoped that contributors will make a sincere effort to conform to the foregoing suggestions. Reprints of these instructions are available from the editors on request. Papers that are otherwise acceptable for publication in *MICROPALEONTOLOGY* but which depart seriously from the style requested will be regretfully returned to their authors for revision.

The "Catalogue of Foraminifera" in microfilm

The *CATALOGUE OF FORAMINIFERA* is now out of print. The last printed set has been sent out, and efforts to recover used sets have just about exhausted the possibilities of that source of supply. A reprinting of the fifty-six volumes of the *CATALOGUE* is presently out of the question, and other means of supplying the demand must be found.

Microfilm copies appear to be the best solution to the problem. The entire *CATALOGUE*, completely interleaved, can be reproduced on twenty-five one-hundred-foot rolls of 35 mm. film. The generic and species units can be so disposed that those issued subsequently can be interspliced to maintain the alphabetic arrangement. Good microfilm readers are now relatively inexpensive.

In view of this situation, we plan to offer such microfilm sets of the *CATALOGUE OF FORAMINIFERA* to prospective subscribing members of this Department, in the near future. Membership privileges will be the same as for those members now possessing printed copies of the *CATALOGUE*, except that the *CATALOGUE*, and supplements thereto, will be on microfilm.

Our plans to proceed with this project will be greatly facilitated if we can anticipate the demand for microfilm copies. Consequently, all who are interested are requested to communicate with the Department of Micropaleontology as soon as possible. Classes of membership and other details will be supplied on request.

Review

JOURNAL OF THE PALEONTOLOGICAL SOCIETY OF INDIA, Volume 1, Number 1. 22 x 28 cm., paper bound, ii + 229 + xxvi. Subscription and membership \$8.50 for first year, \$3.50 for subsequent years.

It would be difficult to conceive of a more imposing inaugural issue of a journal than that composed by the Paleontological Society of India. The long awaited journal of the society was delayed in its appearance because of mechanical difficulties which required two printings (first printed late in 1954, reprinted in 1956, date of imprint 1956, distributed in 1957). In addition to front matter containing congratulatory messages from Prime Minister Jawaharlal Nehru and other functionaries, an impressive list of distinguished persons have contributed articles. Among these are Sir W. E. LeGros Clark, Messrs. J. B. S. Haldane, J. A. Orlov, L. R. Cox, C. A. Arnold, F. R. F. von Huene, N. N. Yakovlev, O. H. Schindewolf, B. F. Howell, and P. E. Cloud, Jr. Member authors include President M. R. Sahni, S. R. N. Rao, S. Singh, Y. Nagappa, and others. A lengthy list of goodwill messages concludes the volume.

The journal, which will be published twice a year, will accept papers dealing with all phases of paleontology, paleobotany and archeology, particularly those concerned with the southeastern Asian region. The inaugural number contains thirty-one articles, in the following categories: Introductory and historical subjects, six; general paleontology and philosophy, five; invertebrate paleontology (exclusive of micropaleontology), one; vertebrate paleontology, three; archeology, three; stratigraphy, two; micropaleontology, six. The standards set by this issue will be difficult to maintain. The member authors have indicated their desire for such a journal, and by the nature of their articles have shown the extensive use which will be made of it.

President M. R. Sahni in particular has performed a great service by his very excellent detailed history of paleontology, paleobotany and archeology in India and neighboring countries. This article, complete with geologic sketch maps, stratigraphic charts, and historical data on early efforts in these fields, will serve as necessary documentary material for both the new student and the experienced paleontologist.

The issue is marred only by the fragility of the binding and the somewhat spotty quality of the half-tone plates. In connection with the latter, one is led to suspect that the quality of the original illustrations is often at fault. It is also hoped that the bibliographically disastrous policy of issuing advance reprints of articles (B. Accordi's paper was issued separately in January, 1955) will cease with the first issue. Although the initial cost is rather impressive, the size of the journal is such that subscribers will receive due return. Foreign subscriptions and memberships are to be handled through Dr. Harbans S. Puri, Foreign Secretary of the Society, at the Florida Geological Survey, P.O. Box 631, Tallahassee, Florida.

India possesses a wealth of paleontological material and is both geographically and geologically in a key position. This journal will be welcome shelf company to the previous literature of the region, and is bound to stimulate research there. It is particularly impressive to see the product of one of the newest paleontological societies begun in such an auspicious fashion. The members of the Paleontological Society of India and their editors are to be congratulated.

DONALD F. SQUIRES
Assistant Curator of Fossil Invertebrates
The American Museum of Natural History
New York

news reports

AUSTRIA



RUDOLF GRILL

In the spring of 1957, sad news reached Austria's geologists and paleontologists. It seemed hardly conceivable that one of the best and most promising young men from our ranks, Dr. Klaus Küpper, was no more. Only a few months earlier, he had left us to accept a position in Nigeria. There, in Portharcourt, he died on May 1, 1957, only twenty-six years old, after having undergone an appendectomy. On the occasion of the Geological Society meeting held in Vienna on May 10, 1957, the chairman spoke about the late Dr. Küpper in warm words. With the excellent papers published during the few years of his research activity, he had already earned honorable standing in our branch of science. A detailed obituary, to be published in the "Mitteilungen der Geologischen Gesellschaft" in Vienna, is being prepared.

The following is a report on micropaleontological activities in Austria during 1957. After two years of micropaleontological research in the Alpine Triassic, some preliminary findings have been published. M. Kirchmayer, of the Petrographical Institute of the University of Vienna,

has reported on foraminifera in the "Hauptdolomit" (1957, Austria, Geol. Bundesanst., Verh., pp. 234-239, 1 text-fig.). Edith Kristan, of the Geological Institute of the University of Vienna, has published a paper entitled "Ophthalmidiidae und Tetrataxinae (Foraminifera) aus dem Rhät der Hohen Wand in Niederösterreich" (1957, Austria, Geol. Bundesanst., Jahrb., vol. 100, pp. 269-298, 6 pls.). She described six new genera and subgenera and sixteen new species. The paper also contains a detailed list of literature on Triassic foraminifera.

R. Oberhauser, of the Geological Survey of Austria, has reported the occurrence of *Trocholina* and *Paratrocholina* in the Karnian, and described six new species and subspecies (1957, Austria, Geol. Bundesanst., Jahrb., vol. 100, pp. 257-267, 2 pls.). Contrary to certain former opinions, Upper Triassic in favorable facies may be rich in microfossils. Among the foraminifera there is a predominance of forms with a single tubular chamber, with various types of coiling and different shell materials. The above-mentioned publications deal mainly with such forms. In addition, we find Lagenidae in abundance. Rotaliidae seem to be more frequent than in the Liassic, and sometimes show apertures like *Epistomina* or *Parrella*; *Globigerina*-like forms also seem to occur. Among the agglutinated many-chambered forms, the Trochamminidae are abundant. Ostracodes are sometimes frequent and show very complex morphology. In the accompanying fauna we find small gastropods and *Spirorbis*, sometimes with distinctive sculpture. Skeletal elements of echinoderms, among them unusual types of echinoid spines and holothurian wheels, must also be mentioned. Edith

Kristan and R. Oberhauser intend to report on these faunas in future papers. The ostracodes from these samples are being studied by K. Kollmann, of Rohöl-Gewinnungs A.G., Vienna.

S. Prey, of the Geological Survey of Austria, has published the results of his investigations of the Molasse window of Rogatsboden in the Lower Austrian Flysch zone (1957, Austria, Geol. Bundesanst., Jahrb., vol. 100, pp. 299-358). The stratigraphic part of this paper is based essentially on the study of microfaunas. The few faunas of the Molasse of this window observed to date are generally meager and composed of forms with calcareous tests. They have the character of the older Oligocene Molasse faunas. The ostracodes determined by Kollmann furnish valuable stratigraphic clues.

The underlying tectonic unit of the window, called "Buntmergel-serie" (= Helvetic, upper Albian to Upper Eocene) shows, in the Cretaceous, predominantly arenaceous faunas, but occasionally also *Globotruncana* and other calcareous forms, such as *Reussella szajnochae*, key species of the Senonian. At the Cretaceous-Tertiary transition zone, *Textularia excolata* and *Rzahakina epi-gona* are more frequent. In the Paleogene, on the other hand, *Globigerina-Globorotalia* faunas are more common than purely arenaceous ones. In the Upper Eocene, large *Globigerinoides* are noteworthy.

The overlying tectonic unit of the window, the Flysch (Lower Cretaceous to lower Paleogene) shows poor arenaceous faunas. Globotruncanas are rare, and *Reussella szajnochae* has not yet been found. Toward the end of the Cretaceous,

however, the faunas become somewhat richer and larger. *Rzezhakina epigona* is not infrequent there.

Among papers on microfaunas from the Neogene basins in Austria, a study by A. Tollmann (Geological Institute of the University of Vienna) on the microfauna of the Burdigalian of Eggenburg in the coastal zone of the Molasse (1957, Österr. Akad. Wiss., Math.-Naturw. Kl., Sitzber., vol. 166, pp. 165-213, 7 pls.) should be given first mention. Stratification, lithofacies, and the rich macrofauna led many decades ago to the establishment of four zones, which have now been studied micropaleontologically. Eighty-four species or subspecies of foraminifera were identified, among which one species and one subspecies are new, and, in addition, twenty-two species or subspecies of ostracodes. Among the foraminifera no definite key species can be indicated for the Burdigalian, but the ostracodes seem to be of greater stratigraphic value.

Another important formation in the Molasse zone of Lower Austria is the "Grund" beds, named from the village of Grund. They lie farther toward the interior of the basin, and consist of shales and fine sands. In the literature to date they have been assigned to the Helvetician on the basis of the molluscan faunas. On the basis of geological surface work and the micropaleontological study of numerous samples, R. Weinhandl (1957, Austria, Geol. Bundesanst., Verh., pp. 120-130) now divides the "Grund" beds into a lower part, belonging to the upper Helvetician, and a higher part, belonging to the lower Tortonian. The type locality at Grund seems to belong to the Tortonian portion.

In two detailed publications, C. A. Bobes has reported on his investigations of bryozoan faunas in the Vienna Basin. The first paper (1956, Austria, Geol. Bundesanst., Jahrb., vol. 99, pp. 225-258, 4 pls.) deals with the bryozoan fauna of the marginal facies of the Tortonian near Vienna; the other paper deals with the Bryozoa of the Austrian Sarmatian (1957, Austria, Geol. Bundesanst., Jahrb., vol. 100, pp.

81-114, 4 pls.). No bryozoan species had previously been determined or described from the Austrian Sarmatian. The author describes ten species or subspecies, of which three species and one subspecies are new. In addition, he also discusses the stratigraphic value of the Sarmatian bryozoan faunas, as well as problems of ecology.

Of the foreign guests we welcomed last year in Austria, we wish to make special mention of Professor H. E. Thalmann, with whom we visited some classical Neogene localities in the Vienna Basin.

RUDOLF GRILL
Geologische Bundesanstalt
Vienna

COLOMBIA



VIKTOR PETTERS

Instituto Geológico Nacional

The Paleontological and Pollen Laboratories have been moved from the old Museo Geológico building to modern and spacious new quarters in the Ciudad Universitaria of Bogotá. This will mean a definite improvement in their working facilities.

Micropaleontological work on foraminifera has been limited to routine determinations of field samples, since Dr. H. Buergl has had to devote most of his time to research on Cretaceous megafossils. The Pollen group, under Dr. T. van der Hammen, is compiling a paper on the pollen correlation of the continental Tertiary deposits of Colombia. The group is also engaged in

a study of Pleistocene sections obtained from water wells in the Sabana of Bogotá. Two recent publications by Dr. van der Hammen supplement previous papers on similar subjects: One is entitled "A palynological systematic nomenclature" (Bol. Geol., vol. 4, nos. 2-3, pp. 63-101, 12 pls., 1956), and the second is "Description of some genera and species of fossil pollen and spores" (ibid., pp. 111-117, 2 pls.).

The Boletín Geológico of the Instituto Geológico Nacional in Bogotá has become a very valuable source of information on megafossils, foraminifera, and pollen for paleontologists interested in the stratigraphy of northwestern South America. Steps are being taken to make the quality of the printing more appropriate the high technical standard of the papers which the Boletín publishes.

Mobil Oil Company of Colombia

L. J. Shishkevich has been transferred from Mobil's Anaco camp in Venezuela to Bogotá. He is now in charge of the laboratory, K. Glazewski having been transferred to Mobil's operations in France.

Richmond Petroleum Company

F. Amato has left Colombia and is now a consultant paleontologist in Caracas, Venezuela. He has been replaced by F. Pickett, who is in charge of the laboratory. The latter has been moved from Bogotá to Barranquilla.

Concesionaria de Petróleo Shell Condor

Shell's stratigrapher, A. Maurenbrecher, is in charge of the laboratory. He is assisted by F. t'Hart, paleozoologist, and D. O. Diederix, palynologist.

Texas Petroleum Company

This company was without a paleontological staff after C. M. B. Caudri was transferred from Bogotá to Caracas in 1950. It is now organizing a new group, with Emil Zalesny in charge and Christina Escobar assisting. Zalesny was a student of Dr. Bandy at the University of

Southern California, and Christina Escobar worked for the Richmond Petroleum Company under F. Amato.

International Petroleum (Colombia) Ltd.

Welcome additions to Intercol's paleontological staff are J. A. McCormick, B. Hulsman, and A. C. Broockly. McCormick studied at Indiana University and is with C. G. Allen, R. Biel, and your correspondent in the paleozoology group. Hulsman, a student of Dr. Wilson at the University of Massachusetts, wrote a thesis on hystrichospherids of the Middle Devonian of New York, and Broockly studied foraminifera with Dr. Galloway, worked on Paleozoic invertebrates for the Indiana Geological Survey, and was with Standard Oil of California before joining Intercol. Hulsman and Broockly are assigned to the pollen group, which is supervised by R. E. Malloy. Other palynologists are I. L. Polson and G. Olaya. R. Obando has left the organization.

V. PETTERS

*International Petroleum (Colombia) Ltd.
Exploration Department
Bogotá*

EGYPT



RUSHDI SAID

The inauguration of the University of Asyout, in Asyout, Egypt, in the fall of 1957 was welcomed by all. Dr. S. E. Nakkady, a colleague who is known to many of us, became the head of the Department of Geology at this new university. He is now

busy establishing the department, and has asked me to announce that the University of Asyout is interested in buying back numbers of the *Journal of Paleontology* and the *Contributions from the Cushman Laboratory (and Foundation) for Foraminiferal Research*, as well as a set of the *CATALOGUE OF FORAMINIFERA*, from any person or society. Dr. Nakkady is preparing a study on the biostratigraphy of the Um el-Ghanayem section, Kharga Oasis, Egypt, as well as studies on the Miocene faunas of the Western Desert of Egypt.

During 1957 the Geological Society of Egypt, in collaboration with the National Research Center and under the auspices of the Science Council, published the first number of a new periodical, the *Egyptian Journal of Geology*. This number includes four articles, of which Said and Barakat's "Cenomanian foraminifera from Gebel Asagil, northern Sinai, Egypt" is of interest to micropaleontologists. The subscription price of this journal is L.E. 1 per year. Individual numbers can be obtained for P.T. 50. For all information, kindly write to the Documentation Center, National Research Center, Tahrir Street, Dokki, Cairo, Egypt.

The Science Council intends to publish a series of *Egyptian Reviews of Science*, the first volume of which appeared in November, 1957, as a "Review of Egyptian Geology" in two parts. Part I reviews research concerning Egypt in the fields of historical geology, paleontology, tectonics, geomorphology, and Pleistocene geology, and was written by Rushdi Said. Part II reviews works on economic geology, ground and surface water, soils, and pre-Cambrian geology, and was written by E. M. El-Shazly. An exhaustive bibliography is included. This review may be obtained from the authors or from the Science Council, National Research Center Building, Tahrir Street, Dokki, Cairo, Egypt. The year 1957 was marked by the establishment of a new wholly-Egyptian-controlled oil company, the General Petroleum Company,

which took concessions in northern Sinai and the Gulf of Suez region. Mr. Ghorab, Mr. Kostandi, and Mr. Barkouki participated in the founding of this company.

The micropaleontological unit in the National Research Center is planning a program of study on cores and cuttings obtained from central Sinai and Dabba. This program is being carried out under the guidance of Dr. Ansary, with the help of M. M. Ashry and Miss B. Fakhr.

Dr. A. Osman is back in Egypt after an extended visit to Europe. He was working at the Institut Français du Pétrole, where he received the degree of Dipl. Ing. and was trained in the sedimentological laboratories of the institute. Dr. Osman also worked in the Netherlands on larger foraminifera, under the direction of Professor van der Vlerk, and on palynology, under Professor Flor-schütz.

Mr. Souaya's long-awaited extensive work on the taxonomy of the foraminifera and other microfossils, including algae and Bryozoa, of the Miocene of the Gulf of Suez is now ready for presentation. Mr. Souaya's work is so carefully done that all of us are eagerly awaiting the publication of this paper.

Mr. Bishay has just finished a study on the microstratigraphy of the Asil oil field based on larger foraminifera. The paleontological laboratories of the Sahara Petroleum Company have been strengthened by the addition of a new geologist, S. Johnson, who is examining ostracodes recovered from wells drilled in the large Western Desert concession.

RUSHDI SAID
*Cairo University
Gizeh*

GERMANY



HEINRICH HILTERMANN

The untimely death of Carl A. Wicher on April 3, 1957, deprived the science of micropaleontology of one of its most valued workers, and all of us of a good friend. Formal obituaries have already been published elsewhere (Erdöl und Kohle, vol. 10, p. 328, and Micropaleontology, vol. 3, no. 3, p. 268). In addition, the paleobotanist and palynologist H. P. Thomson died on December 13, 1957. At the time of his death, he was a professor at the University of Bonn. A summary and evaluation of his contributions will be given at a later date, by others who are more familiar with his field of work.

Stratigraphy was the most important subject of micropaleontological publications in Germany during the year 1957. The seventy titles recorded thus far are distributed stratigraphically as follows: Quaternary 5, Tertiary 17, Cretaceous 10, Jurassic 7, Triassic 2, Permo-Carboniferous 8, Devonian-Silurian 11, and general 9. Most of these publications concern specifically stratigraphic problems, and contain more or less brief references to microfossils, or lists of them.

The following three papers concern methods and techniques: 1) On the use of K_2CdI_4 as a non-poisonous heavy liquid (Neues Jahrb. Geol. Pal., Monatshefte, pt. B, pp. 188-189); 2) on the description of a new Philips Contact Radiograph for making transparent x-ray photographs through thin sections (Industrie-Elektrotechnik, Hamburg,

vol. 5, no. 3, pp. 12-19); and 3) a paper by H. Gocht and F. Goerlich, showing that in residues from HCl solution, chitinous remains of Ostracoda and foraminifera can be found, which are useful in taxonomy (Geol. Jahrb., Hannover, vol. 73).

Of the seventy publications recorded, twenty-seven deal in detail with paleontological and taxonomic problems concerning micropaleontology. W. and R. Remy report on spores recovered from Paleozoic fructifications (Pal. Zeitschr., vol. 31), while H. Pflug describes microspores of Eocene age (Neues Jahrb. Geol. Pal., vol. 102). H. Gocht describes forty-six dinoflagellates from the Lower Cretaceous (Pal. Zeitschr., vol. 31), and K. W. Clement reclassifies Jurassic *Gymnodinium* as *Scriniodinium*, n. gen., because of the inner capsule (Neues Jahrb. Geol. Pal., Monatshefte, pt. B, pp. 408-410). With reference to Paleozoic Hystrichosphaeridea, A. Eisenack has presented new observations on their histology and morphology.

Publications on paleozoological subjects are more numerous: H. Hiltermann and W. Koch published a detailed revision and emendation of *Neoflabellina rugosa* (d'Orbigny). In this paper, three of Wedekind's species were reclassified as subspecies, while others were considered invalid (Geol. Jahrb., Hannover, vol. 74). H. Bartenstein, F. Bettenstaedt, and H. M. Bolli report ninety species of benthonic foraminifera from the Lower Cretaceous of Trinidad (Eclogae Geol. Helv., vol. 50).

Papers on conodonts contain descriptions of many new genera and species, as well as important new stratigraphic data. Publications by G. Bischoff, O. W. Walliser, and W. Ziegler, of the Geological Institute of the University of Marburg, should be mentioned here (Hessen, Landesamt Bodenf., Abh., no. 19 and no. 22; ibid., Notizbl., vol. 85; Neues Jahrb. Geol. Pal., Monatshefte, 1957).

On ostracodes there are papers by G. Hartmann, dealing with Recent

marine forms only, by G. Martin (Senckenbergiana Lethaea, vol. 38), and by C. A. Wicher (Micropaleontology, vol. 3) on the taxonomy and ecology of Malm ostracodes. Otoliths and other fish remains, especially those of the Malm, are reported by W. Weiler (Senckenbergiana Lethaea, vol. 38).

German micropaleontologists, especially those working in the petroleum industry, were invited by their French colleagues to visit the important sections of the Tertiary and Mesozoic of Aquitaine. The one-week excursion starting from Biarritz covered numerous localities in the vicinity of Biarritz, Pau, and Bordeaux. There were many opportunities to collect samples. It was a memorable occasion to see the collecting localities of the great French classical authors of paleontology and stratigraphy, especially those of d'Orbigny. We are grateful to our French colleagues for providing this valuable excursion, and we also thank them for their friendship and cordiality.

At the eighty-second meeting for the exchange of results in micropaleontology and stratigraphy, held on May 3, 1957, at Hannover, H. Beckmann spoke on stratigraphy and facies in the Mesozoic and Tertiary of southern England. Other meetings took place on May 20, at Krefeld, on the subject of the Niederrheinische Tertiary, and on July 25, in Berlin, on the stratigraphy of the Northwest German Tertiary. At both meetings there were also discussions of the applications of micropaleontology. All agreed that it is necessary to revise the taxonomy, especially that of the foraminifera.

The meeting of the Geologische Vereinigung was held at Wiesbaden in March, 1957. The theme of this meeting was "The sea in the present and past." Some of the papers read included references to micropaleontological problems, for example, J. Jarke, "The Iceland-Faroe ridge as the boundary between two oceans," and M. Ksiazkiewicz, "Sedimentation in the Carpathian Flysch sea."

At the spring meeting of the Deutsche Geologische Gesellschaft, held March 30, 1957, at Munich, the principal topic was "Petroleum and gas in the Molasse trough." The importance of micropaleontology was stressed in the following papers: F. Bettenstaedt, "Micropaleontological investigations in the Bavarian and Vorarlberg Alps"; H. Hagn, "Connections between the subalpine Molasse and the neighboring Helveticum"; F. Oschmann, "Stratigraphy, paleontology, and facies in the East Bavarian Molasse and the subsurface Upper Cretaceous"; and U. Rein, "Palynological investigations of Molasse stratigraphy."

On the occasion of the meeting of the Geologische Gesellschaft in the Deutsche Demokratische Republik in April, 1957, at Wernigerode, we had our first opportunity to meet and talk with the paleontologists of the East Zone of Germany. At Wernigerode, Wasbuzky presented a paper on "Micropaleontology of the Heimburg and Blankenburg strata (Santonian-Campanian)." These beds were shown in the field on an excursion through the Cretaceous of Blankenburg led by H. Lutzens.

At the annual meeting of the Paläontologische Gesellschaft, held at Freiburg i. Br. in August, 1957, the following papers on micropaleontology were presented: W. Knauff, "Studies on foraminifera of the Lias delta"; H. Nestler, "Isocrinids from the Rügen Chalk"; K.-J. Müller, "Conodonts of the Upper Devonian Independence strata in Iowa"; K. Mädler, "The preparations of single- and multi-grain palynological slides" and "New microphytological investigations in the Posidonienschiefer"; and O. Wetzel, "New microfossils of the Lias, especially of the Posidonienschiefer."

In connection with this meeting, a one-day excursion to Switzerland took place. We were very fortunate in being able to see the excellent teaching materials at the Geological and Paleontological Institute (Bernoulianum) in Basel, which were shown to us by M. Reichel, H.

Schaub, and L. Höttlinger. The models of Globotruncanas and Alveolines developed by Reichel impressed us especially. Many of the visitors wanted to obtain sets of these models for their own use in teaching. We also saw the types of Conrad Gessner (1518-1565), the oldest fossil type specimens in the world, in the Invertebrate Department of the Natural History Museum at Basel, which were shown to us by E. Gascher. On a field trip to the Tertiary of the Hegau, E. Rutte showed us limnic ostracodes in the Höwenegg Pliocene.

At the meeting of the Deutsche Geologische Gesellschaft held on September 6 at Freiburg i. Br., G. Leschick spoke on "Palynological investigations of the stratigraphy of the East Bavarian Molasse trough." At three monthly meetings, the following papers on micropaleontology were presented: At Hannover, on April 10, F. Bettenstaedt spoke on "Biological aspects of micropaleontology and their significance in stratigraphy"; at Wiesbaden, on April 11, H. Doebl presented a paper on "Results of micropaleontological research in the Rheintalgraben"; and in Berlin, on November 29, K.-J. Müller talked on "Possibilities and problems of stratigraphy with conodonts."

On the occasion of the sixtieth birthday of Professor Hermann Schmidt, of Göttingen (November 9, 1957), a colloquium in his honor was arranged at Göttingen by his students. Among others, the following micropaleontological papers were read: A. Rabien, "Stratigraphy by ostracodes in the Upper Devonian of the Sauerland"; J. Wolburg, "Development of species of two Wealden ostracodes"; and H. Scherf, "The Zechstein in Northwest Germany and its microfossils."

HEINRICH HILTERMANN
Amt für Bodenforschung
Hannover

MEXICO



CLEMENCIA TÉLLEZ-GIRÓN

Escuela Nacional de Ciencias Biológicas
Instituto Politécnico Nacional
Laboratorio de Zoología

Micropaleontological activities at the Laboratorio de Zoología, under the direction of Dr. F. Bonet M., are continually increasing in importance. Dr. F. Bonet M., in collaboration with Mario Trejo, is working on a monograph of the family Calcisphaerulidae, which is now in press and will appear soon in the Anales de la Escuela Nacional de Ciencias Biológicas. Mrs. Nelly B. Adis is at present studying the Tertiary coccolithophorids of eastern Mexico. She is at present in New York, for the purpose of comparing her material with that in American collections, as well as to consult the large libraries there. A study of Recent Coccolithophoridae from the sediments of the Gulf of Mexico, collected by Dr. F. Bonet M. during the oceanographic cruise of the S. S. *Jakkula*, has also been started. Mario Trejo is working intensively on the systematics and biostratigraphy of the genus *Nannoceraspis*.

Petroleos Mexicanos
Gerencia de Exploración
Laboratorio de Paleontología

The section of paleontology of the "Laboratorio de Paleontología y Petrografía" of Petroleos Mexicanos has changed its address to Colón No. 7, 1st floor, Mexico 1, D. F., Mexico. In addition to routine work, which consists of the examination of well and field samples as well as thin sections, research work has been in-

creased in this laboratory. The chief paleontologist, María Luisa Robles Ramos, is working on the possible correlation of beds in Mexico with the typical Danian. For this purpose, a large amount of foraminiferal material from the type locality is available. The results will be published in the near future. Paleontologist Yvette Eternod O. is carrying out a study of the systematics of the Upper Cretaceous foraminifera (Campanian-Maestrichtian) of the Tampico-Tuxpan Embayment. A study of the Mexican species of the genus *Rugoglobigerina* from the Upper Cretaceous of San José de las Rusias, Tamaulipas, has been carried out by Alvaro Ponce de León. Dr. Hans E. Thalmann is introducing the study of fossil pollen and spores for the first time in this laboratory.

Under the direction of Dr. F. Bonet M., the following studies are being carried out in this laboratory. Paleontologist A. Becerra has started a paleoecological survey of the Tamabra limestone of the Poza Rica oil field. Dr. F. Bonet M. has recently reported on the presence of *Coskinolina floridana* in surface material from Yucatan. He has also published a paper, entitled "Zonificación microfaunística de las calizas cretácicas del este de México" (Assoc. Mexicana Geol. Petr., Bol., vol., 8, no. 7-8, pp. 389-488, pls. 1-31, 1956).

Your correspondent is studying Ostracoda from wells drilled in the Burgos Embayment, Tamaulipas. The results of this work are comparable with those obtained from the study of the foraminifera in an attempt to establish zones in the Miocene of this area.

CLEMENCIA TÉLLEZ-GIRÓN
Laboratorio de Paleontología
Petroles Mexicanos
Colón No. 7
Mexico 1, D. F.

SCANDINAVIA

This report covers micropaleontological activities in this area since 1954. It excludes Denmark, as micropaleontological activities there in recent years have been reported on by J. C. Troelsen in *MICROPALEONTOLOGY* (1957, vol. 3, no. 2, p. 194). In this and in forthcoming reports from Scandinavia, mention will also be made of micropaleontological research in the Baltic States and the Leningrad district, because of the close affinity in paleontological respect to Scandinavia. Microfossils derived from glacial drift (German: Geschiebe) to the south of the Baltic Sea have come from Baltoscandia, and will also be mentioned in the Scandinavian reports.

FORAMINIFERA

Sweden and Estonia

Most of the microfossils of Baltoscandian origin, inclusive of foraminifera, described by A. Eisenack (University of Tübingen, Germany) previous to 1954 are Geschiebe specimens. In that year he published a paper on Baltoscandian foraminifera, the majority of which are of known origin (*Senckenbergiana Lethaea*, vol. 35, pp. 51-72, 1954). Among them are eight new species from Sweden and Estonia; they range in age from Lower Ordovician to Middle Gotlandian. This material includes the new genus *Archaeochitina*, from the Middle Gotlandian. The provenance of another eight species described previously is also given in Eisenack's paper. The stratigraphic range may be great (e.g., Ordovician to Devonian). Comparison by the author with genera from beds of corresponding age in North America seems to indicate that there are certain prominent differences. The samples were dissolved in hydrochloric acid, so that only agglutinated species and forms with chitinous walls were observed. The author is of the opinion that calcareous foraminifera were in fact few or absent in the Baltic Ordovician and Silurian.

In this connection, attention may be called to a paper published by B. Waern in 1952 (Uppsala, Univ.,

Geol. Inst., Bull., vol. 34, pp. 223-250), in which Lower Cambrian foraminifera were reported from the Baltic Sea area. F. Brotzen is preparing a monograph on Danian foraminifera based on material from southern Sweden and Denmark. R. Reymert (University of Stockholm) has submitted for publication a paper on foraminifera obtained by the Swedish Albatross Expedition from the Mindanão Trough.

Norway

Foraminifera in Norwegian Quaternary deposits have previously attracted interest in connection with studies of other fossils, mainly mollusks, found in these deposits. In recent years R. Feyling-Hanssen (Norges Geol. Undersøkelse) has begun comprehensive investigations of foraminiferal faunas in Quaternary sequences, chiefly in the Oslofjord area. This area is close to the Swedish Bohuslän area, which is likewise classical with regard to shell-bearing Quaternary deposits. The latter have been studied ever since the Seventeenth Century. Foraminifera in these deposits have been examined by H. Munthe (Geol. Fören. Forhandl., vol. 18, 1896), I. Hessland (Uppsala, Univ., Geol. Inst., Bull., vol. 31, 1943), and F. Brotzen (Geol. Fören. Forhandl., vol. 73, 1951). The Oslofjord is also close to the Skagerak, from which living foraminifera have been studied by A. Goës (Sven. Vet. Akad. Handl., vol. 25, 1894) and by H. Höglund (Uppsala, Univ., Zool. Bidrag, vol. 26, 1947).

Feyling-Hanssen published a quantitative investigation of foraminifera in clays from some units of Brögger's Quaternary clay sequence in the Oslofjord area in 1954 (Norsk Geol. Tidsskr., vol. 33, pp. 109-152), namely, the late glacial *Yoldia* clay and *Arca* clay and the postglacial *Isocardia* clay. Transitional beds were not examined sufficiently to permit quantitative data. The author observed sixty-five species, the subspecies *Pullenia quinqueloba minuta* being new. The latter was raised to specific rank and given the new name *Pullenia osloensis* by the author.

in a subsequent paper (1954, *Norsk Geol. Tidsskr.*, vol. 33, pp. 185-196).

In 1957 (Norges Geol. Unders., no. 197, pp. 5-69), Feyling-Hanssen presented a more detailed foraminiferal stratigraphy of the Oslofjord area, dividing the clay sequence into seven units (A-G), correlated with the previous molluscan stratigraphy. A full account of his studies of the foraminiferal representation in the Quaternary clay deposits of the Oslofjord area is in preparation. Feyling-Hanssen has used his foraminiferal stratigraphy for practical dating purposes in southeastern Norway and in the Trondheim area (*Norsk Geol. Tidsskr.*, vol. 33, pp. 185-196, 1954; *ibid.*, vol. 33, pp. 228-229, 1954; Norges Geol. Unders., no. 197, pp. 1-69, 1957; *ibid.*, no. 200, pp. 42-46, 1957).

OSTRACODES

Norway and Sweden

Ordovician and Silurian ostracodes have been under extensive study in Norway and Sweden for the last fifteen to twenty years. A. Öpik's studies on the Ordovician ostracodes of Estonia published in the thirties (Tartu, Univ., Geol. Inst., Publ.) can be said to form the introduction to this period of ostracode research in the Scandinavian countries. It may be recalled that, almost thirty years previous to Öpik's investigations, another important examination of Estonian ostracodes was made by Bonnema, in 1909, treating of Middle Ordovician forms. Far less important are the numerous papers on ostracodes found in North German Geschiebe boulders from the Baltoscandian region. As the provenance of this Geschiebe material is uncertain in many cases, and the descriptions and illustrations unsatisfactory, these ostracodes in fact contribute far less to science than they detract, since they must be taken into account nomenclaturally.

The active period of ostracode research in Sweden and Norway was initiated by a study by Öpik on Lower Ordovician ostracodes from Norway (*Norsk Geol. Tidsskr.*, vol.

19, pp. 117-142, 1939). It was followed by contributions on Swedish Ordovician ostracodes in the forties by P. Thorslund (*Sver. Geol. Unders.*, ser. C, no. 398, 1940), P. Thorslund and G. Henningsmoen (*Uppsala, Univ., Geol. Inst., Bull.*, vol. 32, pp. 343-432, 1948), and I. Hessland (*Uppsala, Univ., Geol. Inst., Bull.*, vol. 33, pp. 97-408, 1949). Henningsmoen started his investigations of Norwegian ostracodes in 1949 (*Norsk Geol. Tidsskr.*, vol. 28, pp. 27-32). After an interval, he published several papers between 1953 and 1955. His frequently cited work, "Classification of Paleozoic straight-hinged ostracodes" (*Norsk Geol. Tidsskr.*, vol. 31, pp. 185-288), and a paper on Middle Ordovician ostracodes (*ibid.*, vol. 32, pp. 35-56), appeared in 1953. In 1954 he published three more papers, one on Lower and one on Upper Ordovician ostracodes (*ibid.*, vol. 33, pp. 41-68 and pp. 69-108, respectively), and the third on Silurian Beyrichiacea (*ibid.*, vol. 34, pp. 15-71). The latter included a revision of the family Beyrichiidae. He enlarged on this subject in an article in *MICROPALEONTOLOGY* (vol. 1, no. 3, pp. 239-246, 1955). Henningsmoen's concept of the taxonomy of the Beyrichiidae has been discussed in several papers, for example by R. Kesling in 1956 (Michigan, Univ., Mus. Pal., Contr., vol. 13, pp. 33-79).

Since 1956, Henningsmoen has been occupied in finishing his thesis, which was published in 1957. The thesis is a large monograph entitled "The trilobite family Olenidae." It comprises 303 pages and thirty-one plates. At present he is spending a year in the United States in research work.

During recent years, Swedish Paleozoic ostracodes have been under study by V. Jaanusson and A. Martinsson at Uppsala University. Jaanusson has specialized in Ordovician ostracodes, and Martinsson in Silurian. They each published several papers between 1955 and 1957. They stress the taxonomic importance of dimorphism and ontogeny; morphologic terminology is also revised

and enlarged. Their papers are well documented and deserve wide notice.

In addition to Upper Ordovician drift boulders from southeastern Finland (*Uppsala, Univ., Geol. Inst., Bull.*, vol. 36, pp. 79-105, 1956), Martinsson obtained his material from a famous Middle Silurian collecting ground on the Island of Gotland, the Mulde marl. For example, the material of *Beyrichia jonesi* treated biometrically by N. Spjeldnaes in 1951 (*Jour. Pal.*, vol. 25) was obtained from this marl. Martinsson published his first paper on Mulde ostracodes in 1955 (*Uppsala, Univ., Geol. Inst., Bull.*, vol. 36, pp. 1-33). It is a quantitative analysis of the ontogeny of the *Primitiopsisidae* larger than 125 microns extracted from a single sample. His data indicate, among other things, that *Primitiopsis planifrons* has six instars. The impetus to this study was given by Henningsmoen's opinion that *Primitiopsis planifrons* is trimorphic. Martinsson showed that this is not true; the third type (Henningsmoen's subadult female type) was referred to the new genus *Clavofabella*, of which two new species were observed in the Mulde material.

The second paper by Martinsson on the Mulde ostracodes (*Uppsala, Univ., Geol. Inst., Bull.*, vol. 37, pp. 1-42, 1956) is a biometric study of a large assemblage with special reference to ontogeny and the development of dimorphism. It appears from his measurements that the number of instars varies: In *Beyrichia* it is maximally nine, in *Primitiopsis planifrons* (Jones) six, in *Clavofabella* five, and in *Thlipsurella discreta* (Jones) only four. The author also demonstrated that the sex ratios are about 50:50 in the majority of the species measured. Parthenogenesis seems to have taken place in *Clavofabella reticulata* (Jones), only females being present. Velar pre-adult dimorphism was indicated in *Clavofabella multidentata* Martinsson, and cruminal dimorphism possibly in *Beyrichia (Beyrichia) dactyloscopica* Martinsson. A new subfamily, the *Leiocyaminae*, in-

cluding the new primitiopsid genera *Leiocyamus* and *Amygdalella*, was proposed.

In a joint paper (Uppsala, Univ., Geol. Inst., Bull., vol. 36, pp. 401-409, 1956), Jaanusson and Martinsson proposed a new genus, *Triemilomatella*, from the Middle Silurian of Sweden (Mulde marl) and England. The dimorphic characters are referred to as histial and are considered to be of prime generic importance. The heteromorph ("female") is loculate (loculae shallow). Because of the locular dimorphism, the new genus, together with *Ctenoloculina* Bassler, *Parabolbina* Swartz, *Tetrasacculus* Stewart, *Bisacculus* Stewart and Hendrix, *Subligaculum* Kesling and McMillan, and *Abditoloculina* Kesling, is classified in the new subfamily Ctenoloculininae (family Hollinidae Swartz). *Triemilomatella* is the earliest loculate holminid genus so far known.

Jaanusson's thesis (Uppsala, Univ., Geol. Inst., Bull., vol. 37, pp. 173-442, 1957) is a comprehensive investigation of southern and central Swedish paleocoopae ostracodes ranging in age from uppermost Llanvirnian to lowermost Caradocian. Dimorphism is thoroughly discussed, being considered to be of paramount importance in paleocoopae taxonomy. The dimorphic types in the Paleocoopae are classified into four main groups, each of which characterizes a superfamily. Several new terms for carapace structures are proposed, and others are redefined; some terms anticipated in the above-mentioned papers by Martinsson and Jaanusson are discussed. The adventral structures, according to Jaanusson's terminology, merit particular interest because the dimorphism exhibited in two of these structures (the velar and histial structures) is obviously of very great taxonomic importance. In consequence of his strong emphasis on the basic taxonomic importance of dimorphism, the author did not erect new species of dimorphic genera unless both dimorphs were known.

The fauna, preserved in limestone and carefully prepared with fine needles, contained sixty-two species,

among which twenty-three are new. They were referred to thirty-one genera, thirteen of which are new: *Cystomatochilina*, *Actinochilina*, *Piretia*, *Tvaerenella*, *Levisulculus*, *Lennukella*, *Protallinnella*, *Tallinnellina*, *Lomatobolbina*, *Oecematobolbina*, *Grammolomatella*, *Parapyxion*, and *Craspedopyxion*. In *Laccochilina* Hessland a new subgenus, *Prochilina*, was proposed. Several proposals were also made with regard to taxa of subfamily, family and superfamily rank. The revision on the superfamily level is far-reaching. The number of paleocoopae superfamilies was raised to seven, namely: *Eurychilinacea*, *Beyrichiacea*, *Kloedenellacea*, *Holinacea*, *Kirkbyacea*, *Leperditellacea*, and *Leperditiaecea*. The four last-mentioned are new. This paper is a substantial contribution to the knowledge of paleocoopae ostracodes in Scandinavia and in general.

Mesozoic and Tertiary ostracodes have been generally neglected in Scandinavia (Denmark and southern Sweden), although foraminifera in these deposits have been examined extensively. The need for an investigation of the corresponding ostracode faunas has long been felt. In the fall of 1957, R. Reyment and W. Berggren, of the University of Stockholm, began an investigation of Upper Cretaceous and Lower Tertiary ostracodes based on material from West Africa, France, Denmark, Sweden, and North America.

The Baltic States

Mention was made above of earlier work on ostracodes in this area. In recent years, geologists in these countries have again directed their interest toward this group of fossils. Their publications are in Russian. A. I. Netskaia reported on Ordovician ostracode assemblages from the subsurface of Latvia and Lithuania and from outcrops in Estonia and the Leningrad area (VNIGRI, Trudy, new ser., no. 60, Moscow and Leningrad, 1952). A new genus, *Mica*, of uncertain family status, was described. One species, referred to as *Euprimitia parkis* n. sp., was subsequently made the genotype of a new loculate genus, *Foramenella*, by

Stumbur in a later paper mentioned below. In 1953, Netskaia treated Ordovician tetradeiidids from the Baltic States and discussed their stratigraphic significance in comparison with the corresponding faunas of other countries, particularly Sweden (VNIGRI, Trudy, new ser., no. 78, Leningrad and Moscow). Several new species referred to *Tetradella*, *Ceratopsis*, *Dilobella*, "Glossopsis" (= *Glossomorphites*), and *Steusloffia* were described.

K. Stumbur treated ostracodes from the Porkuni (Borkholm) stage at the transition between the Ordovician and the Silurian ("Scientific Publications from the State University of Tartu," vol. 42, Tallinn, 1956). Several new species referred to *Primitia*, *Kiesowia*, *Bythocyparis*, and *Steusloffia* were introduced. The new genus *Foramenella* was proposed (see above).

In 1956, L. J. Sarv published a paper entitled "New ostracodes of the Vaasalemma stage (Upper Ordovician)" (Eesti NSV Teaduste Akad., vol. 1, pp. 30-40). Ten new species of common Ordovician genera were described. In 1955 he had published a thesis entitled "The ostracode fauna of the Estonian SSR" (Eesti NSV Teaduste Akad., "Section of Techniques and Physical Mathematics," Tallinn, 1955).

Geologists abroad have also taken up research on Estonian ostracode material. For example, R. Kesling redescribed specimens in American collections (Michigan, Univ., Mus. Pal., Contr., vol. 12, pp. 259-272, 1955). Dimorphism in *Rakverella*, which was incompletely known earlier, was more fully described, with a description and illustrations of the velate structure of heteromorph specimens in *Rakverella bonnemai* Opik. The paper also gives detailed observations on the velum in *Oepikium tenerum* (Opik).

Geschiebe

Kesling (Michigan, Univ., Mus. Pal., Contr., vol. 13, pp. 33-79, 1956) redescribed Geschiebe ostracodes from northern Germany brought to America more than a

century ago. The ontogeny and specific variation of *Beyrichia tuberculata* (Kloden) were studied, and the reasons for considering this species the type species of the genus *Beyrichia* were re-evaluated. *Dibolbina steusloffi* (Krause) and the genus *Dibolbina* were redescribed. Ontogeny and dimorphism in *Kloedenia wilckensiana* (Jones) were studied, and the genus *Kloedenia* was shown to be distinct from *Welleria*.

CONODONTS

Sweden

In connection with studies of other fossils, conodonts have been observed in the Lower Ordovician rocks of Sweden, and have been described on a few occasions during this century. In recent years, M. Lindström, of the University of Lund, has studied this group especially. His material is Lower Ordovician in age and was extracted from limestones and shales. In a paper published in 1954 he described some eighty-five species. Ten genera and some seventy species and subspecies were described as new (Geol. Fören. Forhandl., vol. 76, pp. 517-604). In another paper, published in 1957 (ibid., vol. 79, pp. 161-178), he showed that conodonts can be extracted even from strongly indurated, tectonically disturbed graptolite shales (material from Scotland). The first taxonomic investigation of conodonts from Sweden, by Hadding in 1913, was revised by Lindström in 1955 (Jour. Pal., vol. 29, pp. 105-111).

ALGAE

Sweden

Fossil algae, mainly charophytes, have been studied over a period of several years by H. Horn af Rantzien, of the Paleobotanical Department of the State Museum of Natural History, Stockholm. He has revised fossil charophytes from Central and South America (Svensk Bot. Tidskr., vol. 45, pp. 658-677, 1951), and has described Pleistocene gyrogonites from New Mexico (Bot. Notiser, Lund, pp. 58-66, 1952). The anatomy of gyrogonites from a drill core from Sweden was investigated in oriented thin sections

(Opera Botanica, Lund, vol. 1, pp. 1-83, 1954). This examination yielded eleven new species, representing five genera, three of them new. The age of the gyrogonite-bearing portion of the core was uncertain; it was believed to be either Middle Triassic or Permian (Sver. Geol. Unders., ser. C, pp. 1-16, 1953). The gyrogonites could not furnish any evidence on this point, because Triassic and Permian charophytes had not been investigated in detail at that time. Recent unpublished studies by Horn of middle Keuper gyrogonites from southwestern Poland indicate that the gyrogonites from the Swedish core are of Keuper age.

In 1954, Horn revised some Pliocene charophyte gyrogonites (Bot. Notiser, pp. 1-33), and in 1956 he published a paper entitled "Morphological terminology relating to female charophyte gametangia and fructifications" (Bot. Notiser, pp. 212-259). A check-list of all genera of fossil charophytes, collating scattered information and revising the nomenclature, appeared in MICROPALEONTOLOGY (vol. 2, pp. 243-256, 1956). Jurassic gyrogonites from India were described by Horn in 1957 (Stockholm Contr. Geol., vol. 1, pp. 1-29). They are similar to fructifications of the modern genus *Nitella*, which had been known in the fossil state only from Quaternary deposits.

Horn has been carrying on morphologic and anatomic investigations of the female gametangia and fructifications of some twenty representative types of living charophytes for several years. Calcareous shells are being given particular consideration. The results will be published in 1958. Parallel to this investigation, selected types of Tertiary gyrogonites have been studied, and a paper is in preparation. These two publications are intended to form the basis of revisions of various assemblages of Tertiary gyrogonites.

In addition to gyrogonites, Horn has examined fragments of coralline algae obtained by the Swedish Albatross Expedition in the Mindanao Trough. A brief report has been submitted for publication.

Diatoms have long been recognized as important indicators of salinity in studies of the Quaternary development of Scandinavia, not the least in Sweden and Finland. Several works including analyses of diatoms have appeared in recent years.

Some papers on diatoms from deep-sea samples have been published recently by R. Kolbe, of the Paleobotanical Department of the State Museum of Natural History, Stockholm. This material was collected during the Swedish Albatross Deep-Sea Expedition. One paper deals with diatoms from cores taken in the West Pacific (Swedish Deep-Sea Exped. 1947-48, Rept., vol. 6, no. 1, pp. 1-49, 1954). The assemblage is monotonous, *Coscinodiscus nodulifer* being the most abundant species (about one million specimens in a gram of sediment). Delicate frustules are strikingly few. The reason for the strong predominance of *Coscinodiscus nodulifer* is discussed; it may be due in part to "a specific power of resistance to corrosion not dependent solely on the thickness of its cell walls." The diatoms in the cores are identified and described; special attention was paid to *Coscinodiscus nodulifer*, which was studied very carefully in quantitative biometric respects. This examination is certainly the most extensive ever made on a diatom species; more than 120,000 single valves were measured and recorded. The vertical frequency and size distribution in the cores fluctuates in relation to variations in temperature and in the general circulation of the water in the Equatorial Zone during the Quaternary, as stated by Arrhenius in his comprehensive investigation of the sediments of the Pacific (Swedish Deep-Sea Exped. 1947-48, Rept., vol. 5, 1952).

In a second paper, Kolbe reported on diatoms from cores taken in the northern Equatorial Atlantic Ocean (ibid., vol. 7, no. 3, pp. 151-184, 1955; also see papers in Deep Sea Research, vol. 1, 1953, and in Science, vol. 126, November, 1957). Fresh-water diatoms are present in practically all cores. More than sixty fresh-water species belonging

to different ecologic groups were identified, one of them (*Melosira granulata*) occurring very abundantly (max. 3600 valves per slide). One sample contained fresh-water diatoms exclusively (eighteen species), except for a single fragment of a marine form. "This level gave the impression of belonging to a fresh-water sediment."

Fresh-water diatoms in ocean sediments have been observed several times before, but not in such remarkable quantities as described in the paper under discussion. This phenomenon has already elicited comment in various quarters concerning the reasons for their presence in these surroundings. The author himself is inclined to consider them as having been transported to the ocean by winds and rivers and then carried farther by ocean currents.

Kolbe has also compiled a check-list of Russian literature on diatoms published since 1920, comprising about fifty-five pages and 350 titles. It will be issued in 1958.

POLLEN AND SPORES

Sweden

During the forty years that have passed since L. von Post, of the University of Stockholm, developed the technique of pollen analysis for the dating of Quaternary strata, this method has been used extensively in all Scandinavian countries. It might perhaps be expected that the usefulness of pollen analyses would have been restricted owing to the development of the C^{14} -method, but no indications of such restriction have been noted. Routine analyses as well as special investigations are being carried on just as before, so that pollen spectra are becoming more and more detailed and complete, thus providing further bases for dating.

Age-determinations of characteristic points in pollen diagrams by means of C^{14} -analyses are now in process in Sweden. Some preliminary data have been published. One sequence dated previously by pollen analysis and by glacial-varve chronology merits particular interest (G. Lund-

qvist, Sver. Geol. Unders., ser. C, no. 557, 1957). The correspondence between the age-data is good in this case. Radiocarbon dating of so-called recurrence surfaces in peat beds, dated otherwise by means of pollen, is reported on provisionally by J. Lundqvist (ibid., ser. C, no. 554, 1957).

Investigations of pre-Quaternary palynology are in progress. Upper Cretaceous and Lower Tertiary pollen and spore assemblages are being studied at the University of Stockholm by Annie Skarby, and spores from the Rhaeto-Lias have been investigated by Britta Lundblad (Sver. Geol. Unders.). The age-determination of a critical section was made possible by this investigation (Sver. Geol. Unders., ser. C, no. 547, 1956).

Special palynological laboratories have been in existence for many years in the Scandinavian countries. Professor Gunnar Erdtman's Palynological Laboratory at Stockholm-Bromma probably has the largest existing reference collection of slides of pollen and spores (some 22,000 slides, representing about 20,000 species). Attention should also be called to a check-list of pollen and spore literature ("List on Palynology") edited by Erdtman and appearing yearly (Geol. Fören. Forhandl.). The eighteenth issue (Geol. Fören. Forhandl., vol. 79, no. 4, 1957) comprises about 130 pages and 1600 titles, more than half of which are Russian (these can be purchased from the Geol. Föreningen, Stockholm 50; price \$2.00). The second part of Erdtman's textbook, "Pollen and spore morphology and plant taxonomy," comprising gymnosperms, ferns, and mosses, is now in press.

CHITINOZOA AND HYSTRICHOMORPHA

A. Eisenack, of the University of Tübingen, Germany, has described four new species of Chitinozoa, together with a new genus, *Cyatochitina*, from the Lower and Middle Ordovician of Sweden and Estonia, and a new species from the Middle Silurian of Gotland (Senckenbergiana Lethaea, vol. 36, pp. 311-319,

1955). Seven new species of Lower Silurian hystrichomorphs from the Island of Gotland were also reported on by Eisenack in 1954 (Senckenbergiana, vol. 34, pp. 205-211). One of them is referred to the new genus *Pulvinosphaeridium*. The author remarks that spinose forms are less frequent in these beds than in the Baltic Ordovician.

G. Regnell, of the University of Lund, has described an assemblage of non-spinose cysts from a Tremadocian limestone in southern Sweden; he referred them to the Hystrichomorpha and in particular to the genus *Leiosphaera*. There are about 250 of them per gram, which is an unusually large number. *Leiosphaera* was also mentioned by A. Martinsson from Upper Ordovician drift boulders in southeastern Finland (Uppsala, Univ., Geol. Inst., Bull., vol. 36, pp. 79-105, 1956). One new species was introduced. The pylem area was described in detail.

IVAR HESSLAND
Geologiska Institutet
Kungstengatan 45
Stockholm 6

UNITED STATES - MID-CONTINENT REGION



DOROTHY JUNG ECHOLS

University of Tulsa, Tulsa, Oklahoma

Dr. Edward Heuer has left the Department of Geology at the University of Tulsa, and is now with the Department of Biology at Texas Christian University.

Oklahoma University and
Oklahoma Geological Survey
Norman, Oklahoma

Dr. Carl Branson, Director of the Oklahoma Geological Survey, reports the following news: Dr. L. R. Wilson joined the staff of the School of Geology and of the Oklahoma Geological Survey on September 1. He is teaching plant paleontology and micropaleontology of spores, pollen, and selected animal groups. With W. S. Hoffmeister he is preparing papers on the spores of the coals of the Cabaniss group, the spores of the Mineral coal, the spore floras of the Permian coals of Oklahoma and Kansas, and the hystrichospherids of the Maquoketa shale.

Dr. R. W. Harris is the author of a monograph on the ostracodes of the Simpson group, issued June 1 as Oklahoma Geological Survey Bulletin 75. He is currently working on the microfossils of the Middle Ordovician of northeastern Oklahoma.

Dr. Thomas W. Amsden is working on the conodonts of the Hunton group, and with Dr. A. R. Loeblich is describing the arenaceous foraminifera of the Hunton group. Eugene Tynan is preparing a paper on *Archaeomonas* in the Miocene Calvert formation. He is working on his doctorate at the University of Oklahoma, and under a research grant-in-aid is studying the morphology and stratigraphic distribution of the Hystrichosphaeridae.

Pan American Research Laboratories
Tulsa, Oklahoma

Dr. Aureal T. Cross has resigned from the University of West Virginia and the West Virginia Geological Survey to do micropaleontological work for the Pan American Research Laboratories. Wilgus Creath, a former Washington University student now with Pan American Research, has been most helpful in aiding your correspondent in obtaining news items this year. Creath and Echols have also nearly completed their ostracode check lists, a project started at Washington University several years ago.

University of Wichita, Wichita, Kansas

Dr. Paul Tasch, Associate Professor in Geology, reports that his research on the microfauna of the Maquoketa "depauperate" zone is continuing. The conodonts of this fauna include many new and interesting forms, which are presently being described and prepared for publication. A paper illustrating the mechanism of conodont control of one type of pellet formation in the basal Maquoketa has been sent to *MICROPALEONTOLOGY*. In conjunction with his study of the conchostraceabearing beds of Kansas and Oklahoma, an intense search is being conducted for microfloras and microfaunas. Preliminary results indicate the presence of calcareous and chitinous molt fragments and a single fresh-water ostracode valve in residues. Neither of these has been previously reported.

University of Nebraska
Lincoln, Nebraska

Dr. Walter Sadlick submits the following interesting and informative news letter from a very active department: One master's thesis was recently completed (1956) in the field of micropaleontology, by Paul J. O'Donnell, Jr., entitled "Fusulinids of the Virgil series in southeastern Nebraska." Fusulinids were studied from essentially the middle part of the Virgil series, particularly the Topeka, Elmwood, Tarkio, and Maple Hill formations. All four of the formations were found to contain different species of *Triticites*, suggesting a rather rapid rate of evolution. The Tarkio limestone contains *Triticites callosus* Dunbar and Henbest, 1942, suggesting that the Greenup limestone of Illinois was deposited contemporaneously with the Tarkio, and that it may lie disconformably on the Shumway limestone, with the latter being correlated approximately with strata adjacent to the boundary between the Douglas and Shawnee groups.

In the foraminiferal laboratory an oscillation study of the middle portion of the Upper Cretaceous Fort Hays (lower) member of the Niobrara formation was attempted.

The study was not fruitful, since *Globigerina* constituted 41 to 53 per cent of each sample, *Planulina* about 5 to 8 per cent, *Hastigerinella* 1 to 4 per cent, and *Gumbelina* 26 to 36 per cent of each collection. Thus, planktonic genera constituted at least 86 to 97 per cent of each sample. The genus *Globorotalites* ranged in per cent values from zero to about 7 per cent. The data include an analysis of four samples, each one to two feet thick, in a stratigraphic interval of 43 to 65 feet above the estimated Pierre-Niobrara contact at the Fort Randall Dam (see Bolin, E. J., 1952, South Dakota Geol. Survey, Rept. Invest., no. 70, p. 13). In this same stratigraphic section, 94 per cent of thirty-nine specimens and 93.5 per cent of forty-seven specimens of *Globigerina cretacea* d'Orbigny were found to be dextrally coiled. It is intended to continue this study in the light of Hans Bolli's investigations (1950, Cushman Found. Foram. Res., Contr., vol. 1, pts. 3-4, pp. 82-89).

Dr. M. K. Elias very recently translated an interesting Russian article for Dr. Sadlick: Morozova, V. G., "The foraminiferal superfamily Globigerinidea superfam. nova, and some of its representatives" (Akad. Nauk SSSR, Doklady, vol. 114, no. 5, pp. 1109-1112, 1 text-fig., 1957). Elias' translation of the diagnosis of the superfamily follows: "Shell free, spiral-trochoidal or spiral-helicoidal, occasionally pseudo-planospiral (crypto-trochoidal), consisting of a row of gradually increasing cameræ. Aperture single or multiple, one principal with several axillary ones; occasionally it is absent. Wall calcareous, porous, usually with lightened construction and additional skeletal developments: nodes, needles, cavities. Jurassic to Recent." Four families, one new (Globotruncanidae), are placed in the superfamily; also included are the Globigerinidae, Globorotaliidae, and Hantkeninidae. Three new genera are also proposed.

For those interested in the superfamily classification of the foraminifera, this is the second superfamily

proposed since Glaessner introduced seven superfamilies in his text-book. Smout (1954, British Mus. (Nat. Hist.), Monogr.; see also Smout, 1955, Washington Acad. Sci. Jour., vol. 45, no. 7) introduced the superfamily Discorbidea.

M. K. Elias and G. E. Condra's study entitled "Fenestella from the Permian of West Texas" was published in July, 1957, as Geological Society of America Memoir 70. The study describes thirty-eight species and varieties of *Fenestella*, twenty-seven of which are new. Four are from material collected by Condra in 1937 from the Lower Permian of the western Urals in Russia; the rest are from the Permian of the Glass Mountains, western Texas. A new order of Bryozoa, the Fenestrata, is proposed (op. cit., p. 35). In connection with the Bryozoa, it is interesting to note a paper by G. G. Astrova and I. P. Morozova, entitled "On the taxonomy of Bryozoa of the order Cryptostomata" (Akad. Nauk SSSR, Doklady, vol. 110, no. 4, pp. 661-664), in which three new suborders were proposed, the Fenestelloidea, which includes the reticulate branch type of zoaria, the Ptilodictyoidea, including the bifoliate forms, and the Rhabdomesoidea, including the cylindrical stem type of zoaria.

The key to the Pennsylvanian-Permian fenestellids (Elias and Condra, 1957, op. cit., p. 71) will undoubtedly prove very useful. Since the order Fenestrata is placed in the class Stenolaemata, whose many members have a colonial bud or colonial plexus, those who teach invertebrate paleontology should find text-figure 1 on p. 27, and the discussion of the elements of the wall structure on pp. 25-26, basic lecture material.

The Pennsylvanian fenestellids and *Archimedes* from the Oquirrh formation of Utah, described in Special Paper 53 of the Geological Society of America, are definitely associated with a highly developed *Fusulina*, probably of very late Marmaton (Des Moines) age. Near Logan,

Utah, *Archimedes* occurs with the fusulinid *Wedekindellina* and a new species of *Fusulina* having septal fluting similar to that of *F. leei* and *F. pumila* of mid-Cherokee age. To date, *Archimedes*, a characteristic Mississippian genus in the mid-continental United States, has been collected by Sadlick in Chester, Springer, Morrow and two Des Moines horizons in the state of Utah.

Dr. Krishna Mohan, of Lucknow, India, is visiting the State Museum at the University of Nebraska for a year of study and research under the guidance of Dr. C. Bertrand Schultz. Dr. Mohan is especially interested in problems of intercontinental correlation of the Miocene, in both marine and continental facies, and is also studying petroleum geology and vertebrate paleontology. He will be at the Museum in Lincoln until September, 1958.

**South Dakota School of Mines and Technology
Rapid City, South Dakota**

Dr. Edward Tullis writes that at present there are no studies in progress in the fields of micropaleontology or paleobotany.

**University of South Dakota
Vermillion, South Dakota**

Dr. Robert E. Stevenson reports that the Department of Geology has just instigated a long-range study of the microfossils of the Upper Cretaceous Pierre formation.

**University of North Dakota
Grand Forks, North Dakota**

Dr. Wilson M. Laird, head of the Department of Geology, reports the following news: Everett E. Wilson, a graduate student in the department, has completed his study, reported last year, of the small solitary corals of the Cannonball formation. The manuscript now awaits final preparation for publication. Mr. Wilson has well advanced his study of the foraminifera of the outcropping Pierre formation in North Dakota. He has found an abundance of foraminifera, as well as many ostracodes. These microfossils, together with collections of foram-

inifera and ostracodes from other exposed formations, are awaiting study, but no other work is currently going on.

**University of Minnesota
Minneapolis, Minnesota**

Professor F. M. Swain reports the following: Richard G. Pierce recently received his doctoral degree in the Department of Botany, having completed a thesis on the microflora of the Cretaceous of Minnesota. Dr. John Hall, paleobotanist at Minnesota, served as his advisor. Dr. Pierce is now employed in the Magnolia research laboratory at Dallas, Texas.

Kendall A. Dickinson is studying Miocene and Pliocene Ostracoda from Nevada for a master's thesis. F. M. Swain is studying Middle Ordovician Ostracoda from the eastern United States and Minnesota, and is preparing a paper on Pliocene cladoceran ephippia from Nevada.

University of Missouri, Columbia, Missouri

Activities in micropaleontology, as reported by Professor R. E. Peck, are as follows: Billy A. Allen has completed his M.A. thesis (1957, unpublished), entitled "Foraminifera of the Paynes Hammock sand of Wayne County, Mississippi." In this paper, forty-six species and three varieties, representing twenty-five genera, are described. The foraminiferal fauna indicates a lower Miocene age for the Paynes Hammock.

B. E. Ellis and Jesse Bird Ellis are continuing their statistical study of late Devonian conodonts in an attempt to correlate associated parts and identify the various stages in the development of the species of several genera. Daniel H. Jones has completed his M.A. thesis (unpublished) entitled "Palynology of the Bevier coal of Missouri." He describes sixty-six species from two benches of coal. M. G. Mehl is continuing his study of the basal relations of the Mississippian of Missouri. The study is based primarily on conodont faunas.

Henry Ott has also completed his M.A. thesis (1957, unpublished), a quantitative study of large numbers of charophyte gyrogonites from the Brushy Basin and Salt Wash members of the Morrison formation of the Colorado Plateau and from the undivided Morrison formation of the Front Range. He concludes that quantitative studies can establish general Salt Wash and Brushy Basin equivalents in the undivided Morrison.

Raymond E. Peck has published a paper entitled "North American Mesozoic Charophyta" (U. S. Geol. Survey Professional Paper 294-A, 1957). The thirty-five species and twelve genera of presently known North American Mesozoic Charophyta are described and illustrated. Seventeen species and one genus are new. The paper contains chapters on the morphology, classification, and stratigraphic distribution of Mesozoic Charophyta. Some species are world-wide in distribution.

Mrs. Virginia Smoot has completed her M.A. thesis, entitled "A study on the possibilities of close correlation of widely scattered localities of diverse late Devonian lithologies by means of conodonts." Robert G. Todd has also completed his M.A. thesis (unpublished), entitled "Spore analysis of the 'Alvis' coal of western Missouri." He has correlated this coal with the Mystic coal of Iowa and the Herrin coal of Illinois.

Charles Upshaw is continuing work on his Ph.D. dissertation, which is a study of the palynology of the Frontier formation of the northwestern Wind River Basin of Wyoming. John Wall has almost completed his Ph.D. dissertation, on the micropaleontology of the Middle

Jurassic of Alberta, Canada. Donald Zalusky is working on his M.A. thesis, a study of the conodonts of an undescribed Devonian unit in central Missouri.

Washington University, St. Louis, Missouri

A few new research projects have been outlined, but the major activities in micropaleontology during 1957 represent a concentrated effort to complete tasks previously reported, which have been under way for several years. The important and rewarding task of accumulating good micropaleontologic sample material continues, and this year we have made excellent acquisitions from Germany, France, Israel, and Japan, in addition to several excellent samples from various parts of the United States.

Katherine Schaeffer, who will complete her M.A. thesis in June, 1958, on microforaminiferal assemblages of the Gulf Coast, worked under Dr. Charles Felix during the summer of 1957, in the palynology section of the Sun Oil Company at Richardson, Texas. Dr. Felix's research is primarily concerned with the study of pollen and spore assemblages of the Miocene of the Gulf Coast.

George Gerlach has been admitted to the graduate school as a candidate for the master's degree. His thesis problem has not yet been selected, and at present he is doing some research on ostracodes. During the spring of 1957, Norman Carl did some independent work on extracting and identifying Oligocene "microforaminifera." He hopes to continue with these studies. George Burget, who is interested in working on the Ordovician Decorah(?) ostra-

codes of Missouri, has been called into the army. He expects to be back in graduate school by September, 1958.

Wayne Hill has completed his M.A. thesis (1957), entitled "Ostracoda of the Plattin Bloomsdale member (Middle Ordovician) of eastern Missouri." Eighteen genera and twenty-nine species of ostracodes are described and illustrated, of which one genus and eleven species are reported as new. The Bloomsdale ostracode faunule contains species previously reported from other Black Riveran and Trentonian formations of North America. The European genus *Conchoprimitia* Öpik, 1935, is reported for the first time in North America.

Dr. Henry Andrews, Dean of the School of Botany, has acquired a graduate school grant to continue work on *Foerstia*. He is currently engaged in writing a new text-book of paleobotany. Tommy Phillips, a new graduate student, is taking course work in general micropaleontology. He has been studying the primitive fern *Botryopteris*.

Recent welcome visitors to our laboratory were: Dr. Harold Levin and family, now with Standard of California, Oildale, California; Dr. Charles Felix, palynology section, Sun Oil Company, Richardson, Texas; Paul Beach, Sohio Oil Company, Houston, Texas; and Jack Gouty, Shell Oil Company, New Orleans, Louisiana.

DOROTHY JUNG ECHOLS
Department of Geology and
Geological Engineering
Washington University
St. Louis, Missouri

Directory of correspondents

The following list of correspondents is presented for the benefit of those who wish to submit news items for publication in *MICROPALEONTOLOGY*. Contributors should send such news items to the correspondents reporting for their own areas. Manuscripts of papers submitted for publication should *not* be sent to correspondents. They should be directed to: Department of Micropaleontology, American Museum of Natural History, Central Park West at 79th Street, New York 24, N. Y.

Argentina

ESTEBAN BOLTOVSKOY
Lucio Vicente Lopez 712
Temperley, FCNCR
Argentina

Australia

IRENE CRESPIN
Bureau of Mineral Resources
Civic Centre
Canberra, A.C.T., Australia

Austria

RUDOLF GRILL
Geologische Bundesanstalt
Rasumofskygasse 23
Vienna III/40, Austria

Benelux

J. H. VAN VOORTHUYSEN
Geologische Stichting
Spaarne 17
Haarlem, Netherlands

Brazil

FREDERICO W. LANGE
Caixa Postal, 16
Ponta Grossa, Paraná, Brazil

Caribbean area

PAUL BRONNIMANN
Esso Standard Oil, S. A.
Apartado 4087
Havana, Cuba

Colombia

VIKTOR PETTERS
Exploration Department
International Petroleum (Colombia) Ltd.
Bogotá, Colombia

Egypt

RUSHDI SAID
22, Road 6
Maadi, Cairo, Egypt

France

JEAN CUVILLIER
Laboratoire de Géologie Appliquée
Université de Paris
191, Rue St. Jacques
Paris 5, France

Germany

HEINRICH HILTERMANN
Amt für Bodenforschung
Wiesenstraße 72
Hannover, Germany

Great Britain

TOM BARNARD
University College
Gower Street
London W.C. 1, England

India

S. R. N. RAO
Department of Geology
University of Lucknow
Lucknow, India

Israel

Z. REISS
Micropaleontological Department
Geological Survey of Israel
Jerusalem, Israel

Italy

ENRICO DI NAPOLI ALLIATA
Corso Vittorio Emanuele, 21
Rome, Italy

Japan

KIYOSHI ASANO
Institute of Geology and Paleontology
Tohoku University
Sendai, Japan

Libya

DAVID D. HUGHES
Esso Standard (Libya) Inc.
P. O. Box 385
Tripoli, Libya

Mexico

CLEMENCIA TÉLLEZ-GIRÓN
Petróleos Mexicanos
Laboratorio de Paleontología
Colón No. 7, 1st floor
Mexico 1, D.F., Mexico

Middle East

MAX CHATTON
Qatar Petroleum Company Ltd.
Dukhan, Qatar
via Bahrain Island, Persian Gulf

New Zealand

N. DE B. HORNIBROOK
New Zealand Geological Survey
156, The Terrace
Wellington, New Zealand

North Africa

JEAN MAGNÉ
S. N. REPAL
B. P. 105
Algiers, Algeria

Peru

EDWIN T. ASHWORTH
International Petroleum Company, Ltd.
Talara, Peru

Poland

FRANCISZEK BIEDA
Katedra Paleontologii A.G.-H.
al. Mickiewicza 30
Krakow, Poland

Portugal

JAIME M. FERREIRA
Avenida Duque de Loulé 50-1º
Lisbon, Portugal

Portugal Overseas

ARMENIO T. ROCHA
Avenida Almirante Reis 151-3º E
Lisbon, Portugal

Saudi Arabia

C. D. REDMOND
Arabian American Oil Company
P. O. Box 2013
Dhahran, Saudi Arabia

Scandinavia

IVAR HESLAND
Geologiska Institutet
Kungstengatan 45
Stockholm 6, Sweden

Spain

GUILLERMO COLOM
Isabel II, 23
Soller, Mallorca, Spain

Switzerland

MANFRED REICHEL
Geologisch-Paläontologisches Institut
Universität Basel
Basel, Switzerland

Turkey

A. SUAT ERK
Department of Geology
University of Ankara
Ankara, Turkey

United States - East Coast

RAYMOND C. DOUGLASS
Room 338 U. S. National Museum
Washington 25, D. C., U. S. A.

United States - East-Central

ROBERT V. KESLING
Museum of Paleontology
University of Michigan
Ann Arbor, Michigan, U. S. A.

United States - Gulf Coast

STUART A. LEVINSON
Humble Oil & Refining Company
P. O. Box 2180
Houston, Texas, U. S. A.

United States - Mid-Continent region

DOROTHY JUNG ECHOLS
Department of Geology and Geological
Engineering
Washington University
St. Louis 5, Missouri, U. S. A.

United States - Rocky Mountain region

DANIEL J. JONES
Department of Geology
University of Utah
Salt Lake City, Utah, U. S. A.

United States - West Coast

HANS E. THALMANN
P. O. Box 1978
Stanford, California, U. S. A.

Venezuela

BOGUSLAW J. SZENK
Mene Grande Oil Company
Apartado 709
Caracas, Venezuela

Yugoslavia

SULTANA N. OBRADOVIĆ
Geoloski Institut "Jovan Zujović"
Brankova 15
Belgrade, Yugoslavia

